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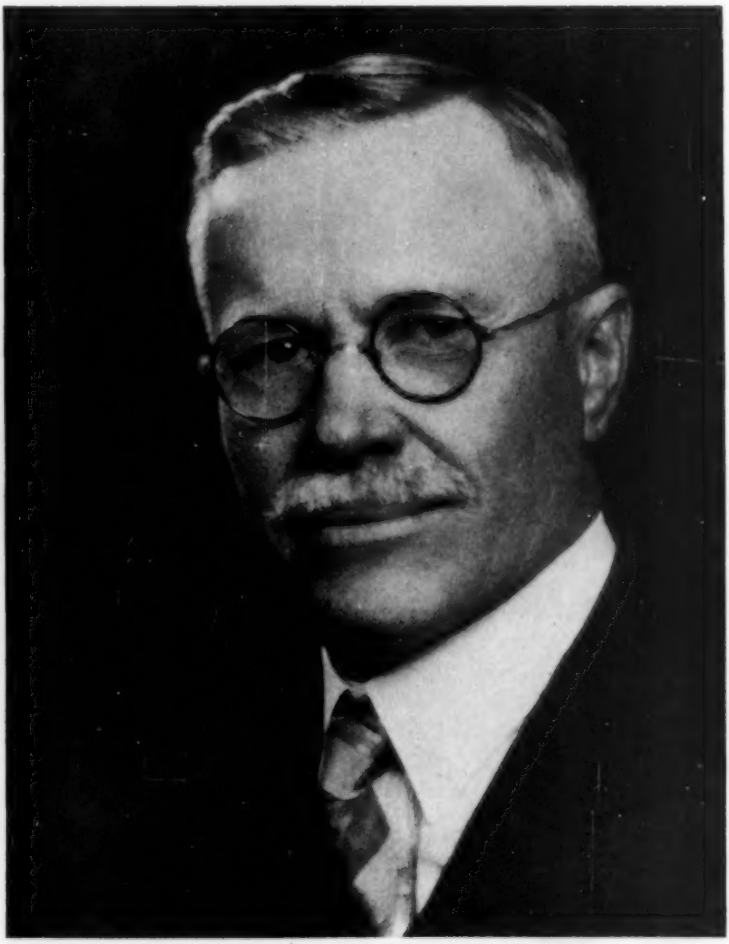

William Lewis Eikenberry

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SCIENCE EDUCATION

VOLUME 40 OCTOBER, 1956 NUMBER 4

AN ANALYSIS OF THE PROCESS BY WHICH A GROUP SELECTS OR REJECTS IDEAS OR BELIEFS *

CHESTER A. LAWSON

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A PROPOSAL that the concept of cultural evolution would be useful in the investigation of human social phenomena led to the hypothesis that the "belief-expectation-test" or *BET* process was a significant factor in human cultural change. It was argued that any change in human culture involves a change in human behavior and that any change in human behavior normally is dependent on a change in beliefs. Thus, the *BET* process which presumably operates in changing beliefs would become a significant factor in human cultural change [1].

Support for the existence of the *BET* process and its significance was found in the writings of Priestley [2], Lavoisier [3], and Henry Adams [4]. Further evidence in support of the hypothesis is presented in this paper. The evidence was obtained from an analysis of a group discussion in which beliefs were presented, debated and either accepted or rejected. The group, known as the Curriculum Committee of the Department of Natural Science at Michigan State University, East Lansing, Michigan, had the task of producing an outline of subject-matter content for a course in Natural Science. The course was to occupy a full academic year divided into three Terms or Quarters. There were to be two one-hour lectures per week, one two-hour laboratory period and one one-hour discussion period per week. The committee also was responsible for the production of a laboratory guide or manual to be used by students.

At the time of the discussion being analyzed in this paper, the committee had in hand a tentative outline of the total course-content and laboratory studies for all but a portion of the Third Term of the course. However, the final discussion concerning the outline and the laboratory studies had not been made prior to the meeting reported below. It was the business of this meeting to make the final decisions.

A tape recording was made of the entire discussion. The record consisted of a series of consecutive utterances made by various members of the group. As a result of these utterances ideas were proposed and either accepted or rejected. The utterances which constituted the discussion presumably were linked together by some mental process in the minds of the committee members. A remark by one person would stimulate a mental reaction in a second person which would lead to another remark by the second person. This investigation is concerned with that which happened in the mind of an individual after he heard a remark and before he reacted. It was assumed that the mental activity was similar to or a part of the *BET* process and the data was examined with this in mind on

* Contribution No. 68 from the Department of Natural Science, Michigan State University. Paper presented at the Twenty-eighth Annual Meeting of the National Association for Research in Science Teaching, Teachers College, Columbia University, April 19, 1955.

the assumption that if the *BET* hypothesis would explain the sequence of utterances in this particular group discussion, then further support would be given to the hypothesis that this process operates whenever beliefs are changed.

In using the *BET* process to explain the behavior of individuals in any group discussion several assumptions were necessary. It was assumed that the human mind exists as an entity or process and that it is composed of at least two elements; meanings and symbols. It was further assumed that meanings are separate from symbols and that meanings cannot be communicated without the aid of symbols or through the use of symbols. Also, it was assumed that meanings are derived from direct perception of an object or of an event or from perception of symbols that signify an object or an event.

A belief is a meaning that stimulates or guides overt behavior in some direction. When the *BET* hypothesis was first formulated the B or *belief* was conceived as a single unitary thought that led to another thought called the E or *expectation*. This was followed by the T or *test* or the actual behavior which either affirmed or denied the *belief* through the affirmation or denial of the *expectation*. As a result of the investigation to be reported below it was recognized that this formula was too simple and required elaboration. The first step in this elaboration was the identification of the elements of the *BET* process with certain elements of the hypothetical syllogism of traditional logic.

One form of the hypothetical syllogism consists of a hypothetical major premise, a categorical minor premise and a categorical conclusion. The hypothetical major premise consists of two categorical propositions which are so related to each other that if the first is true the second must likewise be true, and if the second is false the first must also be false. The first part of the hypothetical proposition, that is, the part introduced by the *if*, is called the antecedent. The second part, introduced by the *then*, is known as the consequent. The categorical minor premise which follows the hypothetical major premise in the syllogism either affirms the antecedent or denies the consequent and from this the categorical conclusion is drawn.

The B or *belief* of *BET* was identified with the antecedent of the hypothetical proposition. The E or *expectation* of *BET* was identified with the consequent, and the T or *test* was identified with the categorical proposition of the hypothetical syllogism.

In the analysis of the following group discussion both the simplified *BET* formula and the hypothetical syllogism of traditional logic were used. A portion of the record of the group discussion is given below in italics. Explanations in terms of the *BET* process and/or the hypothetical syllogism follow each utterance or series of utterances. Letters of the alphabet have been substituted for the names of the members of the Curriculum Committee and each utterance has been given a number.

1. A. Well, we have a task, the task of writing an outline for the Dean and for distribution to the Basic College staff, and B and I would like to get that done this week, or, that is, next week.

Assuming that A's utterance reflected an occurrence in A's mind and that this occurrence can be represented by a portion of the *BET* process and/or a hypothetical proposition the above statement can be rephrased as follows:

Belief or antecedent

If we are to present an outline to the Dean and to the Basic College staff

Expectation or consequent

then we must write an outline, and B and I would like to get that done this week or, that is, next week.

2. B. Beginning next week.

From B's utterance it may be judged that his mental process was the same as A's with the exception of A's ambiguity concerning time. B clarified this ambuigity.

3. A. And so we need an actual decision—a final decision on the total course and so I think maybe the first thing to do this afternoon, B, is to discuss this outline.

The outline referred to in #3 was the tentative outline which had been prepared previously and was in the hands of the committee. Utterance #3 can be explained by interpreting it as a consequence of the following sequence of thoughts.

a. Belief or antecedent
If we are to write an outline
Expectation or consequent
then we must reach a final decision on the course.
b. Belief or antecedent
If we are to reach a final decision on the course
Expectation or consequent
then we must discuss this tentative outline.

4. B. Right, we are planning on that, A.
5. A. Ok.

Again B's remark (#4) reflected agreement and A's "Ok." indicated awareness of that agreement.

6. B. That's the main point here. D objected in your bringing this up but that was one of the main things we wanted to do today.

B continued the mental process begun by A. Each held the same *beliefs* and the same *expectations*. D's objection presumably occurred prior to the committee meeting and apparently was not pressed because it had no visible effect on the progress of the discussion. The interpretation of the utterances so far made was that up to this point the entire committee held the same beliefs and agreed to the sequence of hypothetical propositions; that is, the *beliefs* (B) and *expectations* (E) of *BET* were the same for all members of the committee.

7. C. Shall we take the Terms in order?

The "Terms" referred to in C's question were the segments of the academic year known as the Fall, Winter, Spring and Summer Terms or Quarters. The course was designed to cover three Terms and as most students were in residence during the Fall, Winter and Spring Terms the portion normally taken by the majority of the students during the Fall Term became known as the First Term, the portion taken during the Winter Term became known as the Second Term and the Spring Term material became known as the Third Term of the course.

From C's question it may be judged that he understood and agreed to the foregoing propositions and was suggesting a method of continuing the discussion. The question presumably requested the statement of the proposition: "We shall take the Terms in order." This statement was not made but, on the basis of the following discussion, it can be judged that the committee agreed to the proposition without making the agreement explicit. The logical form would be: "If we are to discuss the outline then we should take them in order of Terms; First, Second and Third."

8. B. I have received four communications only from people on our staff out of 32 members who indicated a preference. Now, I think I ought to read these first.
9. A. What's that about? Is that about—
10. B. (interrupting) About the Third Term.
11. A. Well, have we agreed on the First Term?
12. B. Oh, oh, you wanted to go through the First and Second Terms? I thought—
13. A. If we haven't agreed on them let's do it.
14. B. Yes. I thought we had agreed on the First and Second both.
15. A. No. We have agreed on the First Term but I'm not certain about the Second Term.
16. B. Alright. Everybody in agreement with the First Term?

B's utterance #8 was the beginning of the discussion of the outline. A's response (#9) indicated that A was confused and did not understand B's statement. In the sequence of utterances from #10 through #15 this confusion was clarified and the discussion proceeded again with utterance #16. However, since #16 referred to the First Term and #8 referred to the Third Term it may be judged that B changed his belief.

If the *BET* process operates when beliefs are changed it should be possible to explain this sequence of utterances in terms of the process and to show how the process brought about B's supposed change of belief. This explanation is attempted as follows: First, it was assumed that the utterances of A and B reflected meanings or

thoughts in the minds of A and B. Second, it was assumed that the nature of the meanings or thoughts could be judged from utterances and stated in terms of *BET*. This was done and the judged meanings were classified as either *beliefs* (antecedents) or *expectations* (consequents) and placed in order of their supposed occurrence.

Individual A presumably thought in terms of the following sequence of beliefs and expectations:

a. Belief
If we are to present an outline to the Dean and to the Basic College staff
Expectation
then we must write an outline.

b. Belief
If we are to write an outline
Expectation
then we must reach a final decision on the total course.

c. Belief
If we are to reach a final decision on the total course
Expectation
then we must discuss this tentative outline.

d. Belief
If we are to discuss this tentative outline
Expectation
then we should take them in order of Terms; First, Second and Third.

e. Belief
If we are to take them in order of Terms; First, Second and Third
Expectation
then we should begin with the First Term.

Having reached this point in his thinking, A expected to hear a discussion from the committee members concerning the First Term of the course. Instead he heard B open the discussion with a statement concerning the Third Term and his response was to question B's statement. Presumably B's thinking agreed completely with A's beliefs and expectations as listed above. However, since B began the discussion by referring to the Third Term (#8) it can be judged from his behavior that he added to the above sequence as follows:

f. Belief
If we have already discussed the First and Second Terms
Expectation
then we should begin with the Third Term.

This additional belief led B to expect a discussion of the Third Term. This discussion did not materialize; that is, the T or *Test* of the *BET* process (the response of the committee) did not coincide with his expectation and as a result B was forced to reconsider his belief. When B learned that his belief was in error he changed this belief to one that coincided with that of A and the rest of the committee (#16) and the discussion continued.

16. B. Alright. Everybody in agreement with the First Term?
17. D. Yeah.
18. B. Alright. Now the Second Term. Look that over.
19. C. I have a question on the length of these. Are they going to work out so that they can be accomplished in two hours or at the instructor's discretion to extend into part of the third period?
20. A. Length of what specifically?
21. C. Of the lab studies of the Second Term.
22. A. Which lab studies?
23. C. Well, particularly, I haven't seen the one on the gas laws. We haven't discussed that one on the gas laws, and I wondered. It seemed quite long to me as I look at it.
24. A. Well, I think that this afternoon it might be better not to decide specifically on the number of lab periods devoted to any one of these. Maybe as we examine them we will decide that one may be shortened and the other increased in length. I mean as far as time is spent.
25. C. (Comment unintelligible on recorder.)
26. A. Yes. I think what we need primarily is a decision as to whether *these* are the lab studies and in *this* order and then as far as the time is concerned we can decide that later when we get the total thing in front of us.
27. C. Just so that at some time there is some judgment exercised whether we are printing something that is going to demand or require three hours to complete. I'm personally against that. I'd rather see us plan two hours so that it could go on into the extra hour if the instructors find it needed.

28. B. What he is arguing for is not to have a Deletion Committee for next year.
29. C. That's right.
30. E. Well, in regard to that exercise on the gas laws I might say that at this time in 133 * I put the students in 133 through what was essentially that gas law exercise as it is written. I didn't have copies of it to give to them but where the material was printed there I, in effect, read it to them. And it went through in about two hours and a half under those circumstances.
31. C. Then there is still some time for a chance for an exchange of questions in the latter part of the third hour?
32. E. Yes.
33. C. That sounds alright to me.
34. A. And the one on the theory of the atom; Would you think that would be a two-hour affair?

Utterances # 19 through #27 indicated a conflict between A and C. When B (#18) suggested a discussion of the Second Term, C responded in utterance #19 by questioning the length of the laboratory studies. In utterances #20 and #22 A asked for a clarification of C's question. A then suggested (#24 and #26) that the discussion should go in another direction. C, however, persisted in discussing the length of the laboratory studies and in this he was supported by B and by E which is shown in the series of utterances from #26 through #33. Finally, A indicated that he had agreed to follow C's suggested direction for the discussion by asking a question concerning the length of the next laboratory study (#34).

This sequence of utterances can be explained in terms of the *BET* process by inferring that A's thinking was as follows:

Belief
If what we need primarily is a decision as to whether *these* are the laboratory studies and in *this* order
Expectation
then we should discuss the suitability of the laboratory studies and their sequence of order.

And C's thinking may be stated in this manner:

Belief
If what we need is some judgment concerning the printing of laboratory studies that are going to demand or require three hours to complete
Expectation
then we should discuss the length of the laboratory studies.

A and C were operating on the basis of different beliefs hence their expectations also differed and a conflict resulted. However, the discussion which was the test of the *BET* continued along C's direction. Thus the test confirmed C's expectation. It was contrary to A's expectation and A changed his belief. It should be noted that this change in A's belief empirically demonstrated the *BET* thesis that a belief is changed when one's expectation is contrary to fact.

The remainder of the discussion on Term Two was concerned with the length of the laboratory studies and was omitted from this paper. The Third Term which was discussed next contained the subject matters of geology and evolution. The tentative lecture outline allotted four weeks for the study of geology and six weeks for the study of evolution. The tentative laboratory studies that had been written to correlate with the lectures were completed for the first six weeks of the Term and consisted of the following subjects with the time allotted for the completion of each:

The Identification and Classification of Minerals, Two Weeks
The Identification and Classification of Rocks, Two Weeks
The Identification and Classification of Animals, One Week
The Identification and Classification of Plants, One Week

The laboratory studies for the remaining four weeks of the Term were not completed but they were to be concerned with evidence of evolution, populations in relation to evolution and the races of man.

It should be noted that the time of distribution of the lecture outline gave a preponderance of the time to evolution while the time distribution of the laboratory gave six weeks to classification and four weeks

* 133 refers to the course number of a series previously taught in the Physical Science Department.

to topics considered more directly related to evolution. This over-emphasis of classification in the laboratory became a significant point of issue.

The discussion began with the reading of letters (utterance #8) written by staff members expressing their opinions concerning the proposed outline. Following the reading of the letters the discussion was opened by C.

35. C. Is the problem one of topics or the apportionment? Time spent on it?

36. A. I think the problem is primarily this as far as the various staff members are concerned that I've talked with: That they consider that evolution as a concept is far more important than classification as a concept and here we have six weeks devoted to classification out of a possible ten which is out of balance according to their point of view. Now if classification could be included within evolution as a part of evolution then I think that the argument might be turned around. But, as it is presented here, the classification comes before evolution and in terms of the outline has no apparent relation to it, though, obviously, the authors of the classification studies did not have that in mind. But, I think the fact is—as far as our experience is concerned—that when you give classification before you give the evolution theory that it becomes just a study in classification. You'll recall years ago when we started classification in the First Term of Biological Science * that we felt that we had to introduce some evolution there to make it meaningful and significant and some of us really went into evolution at great length on that.

37. B. In short, the six studies don't appear really functional as far as evolution is concerned.

Utterances #35, 36 and 37 opened the discussion with a statement of the problem to be solved by the discussion. The problem was to change the laboratory manual so that it would reflect the staff's concept of a proper balance between evolution and classification. A stated in #36 "That they (the staff) consider that evolution as a concept is far more important than classification as a concept and here we have six weeks devoted to classification out of a possible ten which is out of balance according to their point of view."

The task of the committee was to change the laboratory manual so that it would conform to the stated belief of the staff. In terms of the *BET* process this amounted to changing the beliefs of the authors of the manual so that they would behave, that is, write in a manner consistent with the expectations of the staff.

The first suggestion to be offered follows.

38. H. Is it possible to have one study on the changes in the earth, the evolution of the earth, of the landscape features and the geological changes and dispense with the descriptive aspect of that thing? Get away from four weeks of it and get it down to one week?

This proposal, if accepted, would have solved the problem by reducing the laboratory time spent on classification to zero. However, the proposal was rejected. Why? The following utterances give a clue to the answer.

39. F. In your lectures that's what you're going to talk about during those four weeks.

40. A. The problem, H, is that doing something in the laboratory that the students can do. You see we can't bring these mountains and things into the laboratory and we can't take the students out to them and so a——

41. B. (Interrupting) That will be talked about in lecture.

42. A. Umhum.

43. H. Still seems heavy on classification.

In order to explain why the committee rejected H's proposal #38 it is necessary to assume that behavior may have more than one result, or, in terms of the *BET* process, a given belief may be followed by more than one expectation, and that if at least one of these expectations leads to a serious conflict the belief is rejected. For example H's reasoning may be judged to be as follows:

Belief

If we have one laboratory study on the changes in the earth, the evolution of the

* Biological Science refers to course which preceded Natural Science in the Basic College at Michigan State University, East Lansing, Michigan.

earth, of the landscape features, and the geological changes

Expectation

then the laboratory outline will reflect the belief of the staff that evolution is more important than classification.

The change in the laboratory outline suggested by H would have resulted in a resolution of the conflict between the staff's expectation of what the laboratory outline should reflect and what it actually did reflect. However, if H's proposal were accepted it also would have led to another conflict which can be illustrated by rephrasing comments of F, A and B (#39, #40, #41). F and B's utterances, "In your lectures that's what you are going to talk about during those four weeks" and "That will be talked about in lecture," may be interpreted as the results of the following sequence of thought:

Belief

If we have one laboratory study on the changes in the earth, the evolution of the earth, of the landscape features, and the geological changes

Expectation

then we will be doing the same thing in laboratory that we will be doing in lecture.

This expectation conflicted with the belief or proposition of F and B: "We should not do the same thing in laboratory and in lecture." Hence, F and B rejected H's proposal. A's rejection of H's proposal presumably was the result of the following argument:

Belief

If we have one laboratory study on the changes in the earth, the evolution of the earth, of the landscape features, and the geological changes

Expectation

then either we would have to bring the mountains into the laboratory or bring the students to the mountains.

A rejected this expectation as impossible of attainment and as a result rejected H's proposal.

From these actual case histories, it appears that the testing of any given belief, say B_1, involves the deduction of all its anticipated expectations or consequences and if any one of the latter, say E_1 leads to a serious conflict with another belief, say B_2, the first belief, B_1, is likely to be rejected. However, there is an alternative possibility in that B_1 may be retained and B_2 rejected. The actual selection of one over the other appears to be a function beyond the scope of the *BET* process. This function is a judgment concerning the relative value of the two beliefs. Presumably the belief having the greater value to the individual is retained.

After H's effort to resolve the conflict failed, A made an attempt. He suggested:

44. A. There's one point that was made by someone: that it has been our policy in the past to attempt to keep the laboratories ahead of the lecture, at least one week, and so it would be reasonable to assume that we might drop one week of the first three and still keep the lectures on geology in relation to the laboratories. In other words, one of the problems was the matter of lecturing or having something in lecture which would correlate with the laboratories. We could still talk four weeks in the lecture on geology even if we had three weeks of laboratory on geology. So from that point of view it could be cut down. Now whether the lab studies themselves could be cut down is another matter.

This utterance can be rewritten as follows:

a. Belief

If it has been our policy to keep the laboratories ahead of lectures and at the same time to correlate the lectures and the laboratory material

Expectation

then we could omit one of the four weeks in laboratory and still maintain correlation.

b. Belief

If we can omit one week of laboratory

Expectation

then we can cut down the number of laboratory periods on classification by one week.

A's argument led to the test of whether the laboratory studies could be cut down. If they could be cut down the test would not be in conflict with the last expectation of the argument and a solution to the problem would have been found. Thus A's argument led to a specific test with the following results:

45. C. Difficult—in order to talk about the material—this problem—we haven't seen the material.
46. G. No. That's what I was going to say. I wouldn't know. . . .
47. B. Well that is the problem that we have had right from the start. That is why, even though most of us would have wished for a nice outline to begin with it never came about because you never knew what was in the lab study to do with; what to do with it—so, that's the same problem again. I'm sure that E and K (authors of the studies) would say that those are pretty heavy studies. They cannot be cut very easily, but, of course, we can always do something like that if it's absolutely necessary.

Utterances #45, #46 and #47 indicated a lack of knowledge concerning the laboratory studies and that the committee could not make the test required by A's argument. Hence the argument remained uncompleted and failed in its attempt to solve the problem. However, A tried again offering another possible solution.

48. A. Well, would it help any if we did this: Let's use—assuming that the first four weeks are to be as they are stated here—can we cut the biology classification down to just one, the animals, and put them at the tail end prior to the evolution of man and, thus, have the theory of evolution to work with in discussion of classification? And make the classification fit more meaningfully into the idea of evolution? Now that would mean cutting out half of the classification but what is our function, primary function, in this classification anyway as far as animals and plants are concerned?

Restated in logical form A's proposal becomes:

Belief
If the first four weeks are to be as they are stated here and if we cut the biology classification down to just one (the animals) and put them in the tail end prior to the evolution of man

Expectation
then we would have the theory of evolution to work with in discussion of classification and make the classification fit more meaningfully into the idea of evolution and we would cut out half of biology classification.

49. M. Four weeks of classification of minerals and rocks? Only one of classification of animals? That sounds unbalanced.
50. G. That's what I was going to say.

While A's proposal resolved the original conflict concerning the emphasis on evolution and classification its acceptance led to another conflict in the minds of M and G which may be restated as follows:

Belief
If we have four weeks of classification of minerals and rocks and only one week of classification of organisms

Expectation
then our course will be unbalanced.

The latter expectation conflicted with the belief of M and G that the course should be balanced and as a result they rejected A's proposal.

However, H came to the support of A by suggesting another expectation or consequent of A's belief which H thought would be accepted. This support and the reaction to it was recorded in utterances #51 through #57 which follow.

51. H. Still it meets the needs, though, of the course, I think, to do that.
52. J. What do you mean?
53. G. What needs?
54. H. Well, to bring out the methods of science. What's the point of re-hashing so many times the systems of classification that we have? That's the purpose of this section on classification, isn't it?
55. A. Well, I think it has two purposes.
56. H. That's one.
57. A. Yes. There is a second one.

H's argument presumably repeated A's belief or antecedent and then added another expectation or consequent as follows:

Belief
If the first four weeks are to be as they are stated here and if we cut the biology classification down to just one (the animals) and put them in the tail end prior to the evolution of man

Expectation
then the purpose of bringing out the methods of science will be accomplished.

In utterances #52 and #53 J and G's questions indicated a conflict between H's expectation and their concept of the purpose of this section of the course. In utterances #55 and #57 A indicated partial but not complete agreement with H's expectation or consequent and as a result H did not persist in his argument.

The discussion continued until a decision was finally reached but because the discussion repeated the pattern already described the remainder was omitted.

It was concluded that the *BET* hypothesis is of value in interpreting and explaining the verbal behavior of the group in discussing the course outline and content and in selecting some beliefs over others. On the basis of the evidence presented here it was concluded that thoughts were related in the minds of individuals in a manner that was reflected by the hypothetical syllogism of traditional logic; that the term *belief* of *BET* was the same as the antecedent of the hypothetical proposition of the major premise; that the *expectation* of *BET* was the same as the consequent of the hypothetical proposition; that the *test* of *BET* was equivalent to the categorical proposition that either affirms the antecedent or denies the consequent. It was also concluded that beliefs were changed when the expectation conflicted with the test or in logical terms when the categorical proposition denied the consequent.

The belief was accepted when the test conformed to the expectation. Although this was equivalent to affirming the consequent which is invalid as logical proof, it does express the idea of empirical proof.

The value of the *BET* process in explaining the verbal behavior involved in the selection of beliefs in a group discussion was accepted as confirming evidence in support of the hypothesis that the *BET* process operated whenever beliefs were changed. If such changes in belief are basic to cultural changes then the *BET* process is an essential element in cultural change or evolution.

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DEDUCTIVE SYSTEMS AND THE INTEGRATION OF NATURAL SCIENCE COURSES [1] * †

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THE integration of science courses is relatively easy providing the scope of the course is not too great. The concepts of physics, chemistry and biology serve adequately to synthesize the subject matter so long as the subject matter is physics or chemistry or biology. And even if physics and chemistry are combined it is not too difficult to find concepts that bridge the gap between the two areas so that they can be presented in a significantly related manner.

Such is not the case, however, when all of the natural sciences are combined in a single course. There is no single concept under which the concepts and theories of physics, chemistry and biology can be classified. Thus, if one is to teach natural science the choice is between teaching two, three, or four separate courses in sequence or finding a means of integration outside of the subject matter itself.

[1] Contribution No. 75 from the Department of Natural Science, Michigan State University.

* The author is indebted to Daniel K. Stewart for assistance with the symbolic logic included in this paper.

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At Michigan State we selected the second alternative and attempted to integrate the diverse sciences through the methods of science on the assumption that there was a common core of methodology inherent in any science at any time and place.

This scheme of integration served us only fairly well. There is a thread of methodology that runs through the course, but it is all too often overshadowed by a subject matter theme, with the result that the student is more apt to think of the year long course as being made up of three segments —the first being cellular biology, the second geology and evolution, and the third a combination of chemistry and some physics.

In terms of methodology one area was significantly missing. This area was mathematics. As a method of science it ranks high in productiveness and most certainly should be included. But how? Should we teach arithmetic, algebra, etc.? Would practice in mathematical manipulation give insight into the significance of mathematics for discovery in the natural sciences? If the answer is "no," then what could be done?

The first clue to a possible solution of the problem came as a result of studying logic and the discovery that, in the "Principia Mathematica," Russell and Whitehead [1] had combined logic and mathematics into a single deductive system. The second clue was the rather frequent statement by logicians that scientific theories were deductive systems. If mathematics is a deductive system and if each of the theories or conceptual schemes of natural science is also a deductive system, then we have at hand our much needed common denominator to serve as an integrating theme for a natural science course.

Following up these clues the first task was to discover what a logical deductive system consisted of. The second task was to discover whether or not the theories of natural science were in fact deductive systems.

To illustrate the characteristics of a deductive system I have chosen as an example a deductive system dealing with propositions, and which is generally called in logic "the calculus of propositions."

"The calculus of propositions" consists of (1) primitive terms (ideas) (2) definitions (3) postulates or axioms (4) theorems and (5) rules of operation.

Primitive terms are terms or words that are accepted and used without definition. This does not mean that such terms have no meaning, but that their meaning must be found in another system of ideas and not within the system being constructed. If other terms are brought into the system, it is accomplished by means of definitions. A definition may be thought of as simply a declaration to the reader that a newly introduced term is to mean the same as another term already known. It is recognized that all definitions are redundant, though convenient.

Postulates are statements constructed out of the primitive terms, and are asserted without in any way establishing their validity. Postulates, like primitive terms, are taken as being self-evidently true. Theorems are statements that are inferred by means of the postulates, definitions, and other statements of the system whose validity has already been established.

In the calculus of propositions the primitive terms are (1) "proposition"—symbolized by "p," "q," "r," etc., (2) "alternation"—symbolized by "$\vee$," and (3) "negation"—symbolized by "$\sim$."

Although the notions above constitute the minimum of primitive ideas necessary for the system, three other terms are introduced as definitions to facilitate handling of proof. These are:

(1) "Conjunction"; $(p \cdot q) = \sim(\sim p \vee \sim q)$ Df.
(2) "Implication"; $(p \supset q) = (\sim p \vee q)$ Df.
(3) "Equivalence"; $(p \equiv q) = [(p \supset q) \cdot (q \supset p)]$ Df.

The postulates of the calculus of propositions are:

(1) "$(p \vee p) \supset p$."
This is called the principle of tautology and is exemplified by the statement "If it is raining or it is raining, then it is raining."

(2) "$q \supset (p \vee q)$."
This postulate is the principle of addition. For example, "If it is snowing, then it is either raining or snowing."

(3) "$(p \vee q) \supset (q \vee p)$."
This is the principle of permutation. An example is "If it is raining or snowing, then it is snowing or raining."

(4) "$(q \supset r) \supset [(p \vee q) \supset (p \vee r)]$."
The principle of summation states that in an implication a disjunct may be added to both antecedent and consequent and the implication will still hold. For example, "If clouds imply rain, then wind or clouds imply wind or rain."

(5) "$[p \vee (q \vee r)] \supset [q \vee (p \vee r)]$."
The principle of association states that in the case of an alternation the place of the component parts with respect to the parentheses makes no difference to the truth of the proposition as a whole. "If it is raining or clear or cold, then it is clear, or raining, or cold."

It will be noted that these postulates, from the standpoint of subject matter, appear to be trivial. However, they are stated for what they imply, rather than for what they say, and their implications are significant.

The deduction of theorems is accomplished by the use of substitution and the principles of inference.

Because the postulates of the systems are constructed in such a way that their truth value is always truth, the substitution of one variable for another variable within a postulate will produce a valid theorem so long as that substitution is complete. For example since $(p \vee p) \supset p$ is true the proposition or theorem $(\sim p \vee \sim p) \supset \sim p$, where $\sim p$ is substituted for p, must likewise be true. In another example $p \supset q$ may be substituted for p in $(p \vee p) \supset p$. This produces the theorem $[(p \supset q) \vee (p \supset q)] \supset (p \supset q)$.

In a second type of substitution, known as "definitional substitution," any expression may be replaced by one which is definitionally identical with it. For example given the postulate $q \supset (p \vee q)$, by substituting $\sim p$ for p the expression becomes $q \supset (\sim p \vee q)$. By definition $(\sim p \vee q) = (p \supset q)$. Therefore by substituting $(p \supset q)$ for $(\sim p \vee q)$ in $q \supset (\sim p \vee q)$ we arrive at the theorem $q \supset (p \supset q)$.

Variable substitutions and definitional substitutions are the only substitutions permitted in this calculus of propositions.

The use of the Principle of Inference in deduction is based on the belief that whatever is implied by a true proposition is true. If, for example, "p implies q" is true, and also that "p" is true, then this principle enables us to assert "q" alone. The process of inference cannot be reduced to symbols. The sole record that an inference has taken place is the detached consequence from some conditional proposition, i.e. some "q."

The above is an overly brief exposition of the nature of a deductive system which fails to do justice to the meaning and power of such systems. However, it does contain the elements of a deductive system and for our present purpose this is all that is needed. To summarize a deductive system consists of (1) primitive terms (2) definitions (3) postulates (4) theorems (5) rules of operation such as substitution and inference by which theorems may be deduced from the postulates. It should be mentioned, also, that once a theorem has been proved it may be used as a premise for the deduction of other theorems. This characteristic permits deductive systems to grow.

The first task attempted in this paper was to determine the nature of a deductive system. The second task was to determine whether or not the theories of science were deductive systems. For this purpose a translation of "Experiments in Plant-Hybridisation" by Gregor Mendel [2] was examined. This publication represents the beginning of the modern theory of inheritance which has been and continues to be a fruitful scientific theory. But is it a deductive system? To answer this question Mendel's paper was analyzed for primitive terms, definitions, postulates and evidence of the use substitution and inference. It was argued that if significant portions of Mendel's paper could be demonstrated to have the characteristic parts and relations of our model deductive system above then at least this theory was a deductive system.

For this purpose, this report represents an analysis of the first thirteen pages of "Experiments in Plant-Hybridisation." The complete analysis and development of the various ramifications would carry us beyond the scope of our primary intention.

Mendel's opening paragraphs contain terms which he did not define. These were terms derived from earlier studies of heredity which Mendel presumably assumed would be understood. The opening paragraphs were as follows: "Experience of artificial fertilization, such as is effected with ornamental plants in order to obtain new variations in color, has led to the experiments which will here be discussed. The striking regularity with which the same hybrid forms always reappeared whenever fertilization took place between the same species induced further experiments to be undertaken, the object of which was to follow up the developments of the hybrids in their progeny."

"Those who survey the work done in this department will arrive at the conviction that among all the numerous experiments made [by others], not one has been carried out to such an extent and in such a way as to make it possible to determine the number of different forms under which the offspring of hybrids appear, or to arrange these forms with certainty according to their separate generations, or definitely to ascertain their statistical relations."

"The object of the experiment was to observe these variations in the case of each pair of differentiating characters, and to deduce the law according to which they appear in the successive generations."

The above three paragraphs contain terms which might be classified as primitive terms of a deductive system which Mendel expected to create. Some of these primitive terms are: fertilization, artificial fertilization, variations, varieties, hybrid forms, species, progeny, offspring, generations, differentiating characters.

In the first thirteen pages of his paper Mendel defined four terms. The terms and their definitions were:

(1) Dominant Character
". . . those characters which are transmitted entire, or almost unchanged in the hybridization, and therefore in themselves constitute the characters of the hybrid, are termed the dominant. . . ."

(2) Recessive Character
". . . those [characters] which become latent in the process [are] recessive."

(3) Parental Character
"As a parental character it must pass over unchanged to the whole of the offspring; . . ."

(4) Hybrid Character
". . . as a hybrid character, on the other hand, it must maintain the same behavior as in the first generation, [i.e. produce offspring of which ¾ are dominant and ¼ are recessive]."

Mendel used undefined or primitive terms to define dominant, recessive, parental and hybrid characters and this is exactly what is required of definitions in a deductive system. Furthermore Mendel used both primitive and defined terms to formulate his postulates. Thus, at first glance it would seem that Mendel's paper contained another characteristic of a deductive system. On second glance, however, it became apparent that there is a difference in the nature of definitions. Definitions of a deductive or logistic system are called "nominal" or "verbal" by logicians and are not intended to be either true or false. Definitions such as Mendel used are called "real" or "definitions of equivalence" and are either true or false. Thus Mendel's definitions apparently are not analogous to those of a deductive system. Instead they are analogous to the postulates of such a system and belong in the same category as the postulates listed below.

The postulates of a deductive system are the foundation of the system. If they are true then all valid deductions from them are likewise true. Any series of related but non-contradictory statements may be used as postulates in developing a system, but if it is intended that the system shall have any relevancy to truth as we know it, then it is important that the postulates be as near the truth as humanly possible. The primary source of human truth is human experience and for a scientist this means

direct empirical observation. Mendel made observations on plants, he bred them and observed their offspring and then he wrote statements which described his observations. The original statements consisted of descriptive statements of the immediately observed facts. On the basis of these facts Mendel made generalized statements. It was these general statements which were identified as the postulates of Mendel's deductive system.

Nine postulates were identified in the first thirteen pages of Mendel's paper. They are:

1. "In all, thirty-four more or less distinct varieties of Peas were obtained from several seedmen and subjected to a two year's trial. . . . All the varieties yielded perfectly constant and similar offspring; at any rate, no essential difference was observed during two trial years. For fertilization twenty two of these were selected and cultivated during the whole period of the experiments. They remained constant without exception."
2. "The various forms of Peas selected for crossing showed differences. . . ."
3. "If two plants which differ constantly in one or several characters be crossed . . . each pair of differentiating characters . . . unite in the hybrid to form a new character . . . [which] resembles that of one of the parental characters so closely that the other either escapes observation completely or cannot be detected with certainty."
4. "It was further shown by the whole of the experiments that it is perfectly immaterial whether the dominant character belongs to the seed-bearer or to the pollen-parent, the form of the hybrid remains identical in both cases."
5. "In [the F_2] generation there reappear, together with the dominant characters, also the recessive ones with their peculiarities fully developed, and this occurs in the definitely expressed average proportion of three to one, so that among each four plants of this generation three display the dominant character and one the recessive."
6. "Those forms which in the first generation [F_2] exhibit the recessive character do not further vary in the second generation [F_3] as regards this character; they remain constant in their offspring."
7. "It is otherwise with those which possess the dominant character in the first generation [bred from the hybrids]. Of these *two*-thirds yield offspring which display the dominant and recessive characters in the proportion of 3 to 1, and thereby show exactly the same ratio as the hybrid forms. . . ."
8. ". . . while only *one*-third remains with the dominant character constant."
9. "The members of the first generation [F_2] spring directly from the seed of the hybrids [F_1]. . ."

The statements which were identified as theorems or deductions from the postulates are as follows:

1. "It is therefore demonstrated that, of those forms which possess the dominant character in the first generation, two-thirds have the hybrid character,
2. while one-third remains constant with the dominant character."
3. "The dominant character can have here [F_2] a double signification—vis. that of a parental character, or a hybrid character.
4. "The ratio of 3 to 1, in accordance with which the distribution of the dominant and recessive characters results in the first generation, resolves itself therefore in all experiments into the ratio of 2:1:1 if the dominant character be differentiated according to its significance as a hybrid character or a parental one."
5. "It is now clear that the hybrids form seeds having one or other of the two differentiating characters, and of these one-half develop again the hybrid form, while the other half yield plants which remain constant and receive the dominant or the recessive in equal numbers."

The deduction of theorems from the postulates of a deductive system is accomplished by the use of substitution and inference. If Mendel's theory of inheritance is a deductive system it should be possible to demonstrate that his theorems can be deduced from his postulates by the same procedures. Of course, it is impossible to know whether or not Mendel actually thought in this manner to produce the statements that were identified above as theorems, but if it can be shown that his theorems can be produced by means of substitution and inference, then support will be given to the interpretation of Mendel's theory as a deductive system.

The following is a logical argument using arbitrary symbols in place of words which demonstrates that the operations of formal logic can produce the same conclusions (theorems) that Mendel produced.

Not all of the statements listed above as postulates were essential for the first five theorems. However, two of Mendel's definitions were used as postulates, and two postulates were essential that Mendel did not state. These unstated, enthymemic

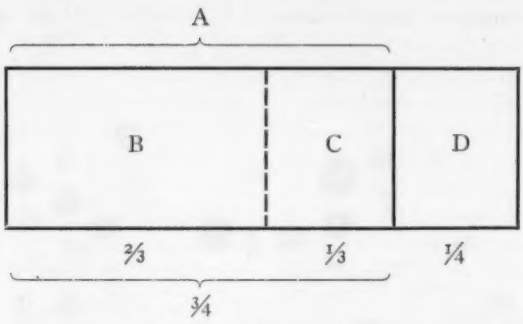

FIGURE 1. F_2 Populations.

Postulates (designated by "Pp")

1. $[(P \cdot P) \supset (A \cdot D)] \supset (P \supset K)$	Pp. (from definition 4).
2. $C \supset C$	Pp. (from postulate 8).
3. $[(P \cdot P) \supset P] \supset (P \supset N)$	Pp. (from definition 3).
4. $B \supset (A \cdot D)$	Pp. (from postulate 7).
5. $A \supset (B \cdot C)$	Pp. (assumed).
6. $L \supset M$	Pp. (from postulate 9).
7. $M \supset (B \cdot C \cdot D)$	Pp. (assumed).

Theorem 1. $B \supset K$

1. $[(P \cdot P) \supset (A \cdot D)] \supset (P \supset K)$	Quote Pp. 1.
2. $B \supset (A \cdot D)$	Quote Pp. 4.
3. $B \supset K$ from 1·2 by Sub., Id., Int., M.P. (Q.E.D.)	

Theorem 2. $C \supset N$

1. $[(P \cdot P) \supset P] \supset (P \supset N)$	Quote Pp. 3.
2. $C \supset C$	Quote Pp. 2.
3. $C \supset N$ from 1·2 by Sub., Id., Int., M.P. (Q.E.D.)	

Theorem 3. $A \supset (N \cdot K)$

1. $B \supset K$	Quote Theorem 1.
2. $C \supset N$	Quote Theorem 2.
3. $A \supset (B \cdot C)$	Quote Pp. 5.
4. $A \supset (N \cdot K)$ from 1·2·3 by Distr., Syll., Adj. (Q.E.D.)	

Theorem 4. $(B \cdot B) \supset (B \cdot C \cdot D)$

1. $(B \cdot B) \supset (A \cdot D)$	Quote Pp. 4, Id., Sub., Int.
2. $A \supset (B \cdot C)$	Quote Pp. 5.
3. $(B \cdot B) \supset (B \cdot C \cdot D)$ from 1·2 by Distr., Syll., Adj. (Q.E.D.)	

Theorem 5. $L \supset (B \cdot C \cdot D)$

1. $L \supset M$	Quote Pp. 6.
2. $M \supset (B \cdot C \cdot D)$	Quote Pp. 7.
3. $L \supset (B \cdot C \cdot D)$ from 1·2 by Syll. (Q.E.D.)	

postulates are designated "assumed" below and presumably were as essential for Mendel's thinking as for the following logical argument.

In the argument below, the symbols have the following meanings: "P" refers to any unspecified character.

"A," "B," "C," "D" refer to particular characters. "A," "B," "C" are dominant characters, "D" is a recessive character.

"K" refers to hybrid characters.
"N" refers to parental characters.
"M" refers to offspring.
"L" refers to seeds.

The relation of the symbols to the numerical values in the F_2 generation bred from hybrids is shown in Figure 1.

In the F_2 generation (Figure 1), ¾ of the population is represented by B and C,

while ¼ is represented by D. But ⅔ of the ¾'s is B, and ⅓ of the ¾'s is C. Therefore, the quantitative value of B with respect to the whole population is ½; of C is ¼; and D is ¼. By clearing of fractions this proportion is expressed in whole numbers as 2:1:1 which is precisely what Mendel obtained, and stated as his fourth theorem.

The identification in Mendel's paper of primitive terms, postulates and theorems and the demonstration that the theorems can be deduced by the operations of substitution and inference support the hypothesis that theories of science are deductive systems. A similar analysis of other theories of science is needed.

If such analysis yields similar results the problem of integration in natural science courses will be less difficult than at present. Such courses can be developed using the form of a deductive system as the basic pattern. Each theory can then be treated as an example of this basic pattern, and the relationship between different theories can be demonstrated to be a relationship of similar elements between systems.

The function of this relationship between systems has not yet been established but evidence not reported in this paper suggests that, when two systems are related, deductions in one system can be applied to the other system. If this is true it explains the relation of mathematics to scientific discovery, and also it offers a useful approach to the teaching of mathematics in natural science courses.

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WILLIAM LEWIS EIKENBERRY

To William Lewis Eikenberry goes the Second Science Education Recognition Award. It is altogether proper and fitting that Doctor Eikenberry, the oldest member of the National Association for Research in Science Teaching should be so honored. He was born in Waterloo, Iowa, July 12, 1871, the son of William E. H. and Susan Berkley Eikenberry. He was a student at Mt. Morris Academy and College, 1887–1892. He earned a B.S. degree from the University of Michigan in 1894. He studied at the University of Chicago in 1901–03 and 1913–14. Mt. Morris College awarded him an honorary D.Sc. degree.

A long and distinguished career in teaching science began as a science teacher in the Mount Morris College in 1894. Here he remained until 1902. In 1903 he became a botany teacher in Central High School of St. Louis, Missouri. A year later he became head of the botany department in the McKinley High School, St. Louis, a position he held until 1909. During 1909–16 he was instructor in botany at the University High School, University of Chicago. In 1916 he became assistant professor of the Teaching of Science, School of Education, University of Kansas, Lawrence, Kansas. He was made associate professor in 1919 and remained at the University of Kansas until 1922. He accepted a position at the Pennsylvania State Normal School, East Stroudsburg, Pennsylvania, as Professor and Head of the Science Department in 1922. This position he held until 1929 when he transferred to the New Jersey State Teachers College, Trenton, New Jersey, to become Head of the Science Department. This position was held until his retirement in 1942. During the war year 1942–43 he was with the training department of Eastern Aircraft, Trenton, New

Jersey; taught in war defense course at Temple University in Philadelphia in 1943; and was a lecturer in physics at the Palmer Physical Laboratory of Princeton University, Princeton, New Jersey, 1943–46. Away from home summer school teaching includes Oregon Agricultural College, Corvallis, Oregon, 1916; City Teachers College of Detroit, Michigan, 1922; and Graduate School of Harvard University, 1925. Thus his active teaching career spans some fifty-two years.

He married Florence Shaw of Polo, Illinois, June 30, 1903. A long and happy married life was terminated by Mrs. Eikenberry's death April 13, 1953. Their son Robert is now Associate Professor of Aeronautical Engineering at Notre Dame University. Dr. Eikenberry is a member of the Church of the Brethren.

Membership in organizations include life membership in the National Association for Research in Science Teaching, Fellow in the American Association for the Advancement of Science, Sigma Xi, American Botanical Society, Central Association of Science and Mathematics Teachers, National Science Teachers Association, Nature Study Society, and Phi Delta Kappa. Dr. Eikenberry is listed in Who's Who in America, American Men of Science, and Who's Who in Education.

Dr. Eikenberry served as President of the Science Section of the N.E.A. in 1939. He has published some ten articles in various magazines and some nine books, pamphlets, and bulletins. Some of the readers of *Science Education* "cut their pedagogical teeth" on one of his early general science textbooks. His books include *Problems in Botany* (1919); *The Teaching of General Science* (1922); *Elements of General Science* (with Otis W. Caldwell) (1914); *Laboratory Manual in General Science* (1922); *Laboratory Problems in General Science* (1924); and *Educational Biology* (with R. A. Waldron) (1929). The *Elements of General Science,* one of the very earliest of the general sceince textbooks, went through several editions.

Over a period of many years, Dr. Eikenberry has been actively engaged in tracing the genealogy of the Eikenberry family. The earliest established date connected with the family is that of the marriage of Martiniss Eikenberg and Anna Maria Dornin in 1723. Their son was Eikenberry's great-great grandfather who came from Germany to this country about 1750 and settled in Lancaster County, Pennsylvania, in 1752. He moved to Virginia in 1790, and to Ohio in 1807. The Eikenberry name was traced back to Von Eichenberg in 1194 in Thuringia, Germany. On his mother's side, Eikenberry traced his family to Switzerland as early as 1547. Dr. Eikenberry published this genealogy in 1955 through the Church Center Press, Myerstown, Pennsylvania.

Over the years Dr. Eikenberry and his son Robert have been very actively engaged in Boy Scout work. Both have received the coveted Silver Beaver Scout Award for their distinguished scout work. This past summer, as for a number of years, Dr. Eikenberry has served as Naturalist at the South Bend, Indiana, scout camp, Camp Tamarack.

As meritorius as are the above listed accomplishments, *Science Education* is honoring Dr. Eikenberry for a still more important reason. He is a Charter as well as a Life Member of the National Association for Research in Science Teaching. Probably more than any other person, he was responsible for the organization of National Association for Research in Science Teaching. The citation read at the Silver Anniversary meeting of the National Association for Research in Science Teaching in Chicago in 1952 honoring charter members said "it was his letter to some 35 educators that got together the first group out of which NARST was born. In recognition of this effort he was chosen the first president of NARST serving during 1928–30. His term as President laid a firm foundation for the subsequent accomplishments of the National Association for Research in Science Teaching. Thus science teachers at all teaching levels owe Dr. Eikenberry a

tribute of gratitude for distinguished leadership in science education.

Nor has Dr. Eikenberry's interest in science education in general, nor in NARST in particular, lagged through the years. He has been a regular, keenly interested attendant at mid-western meetings where his presence has been an incentive to the younger NARST members. His professional spirit, loyalty, devotion to an ideal, and interest is in marked contrast to some others in the science education field who seemingly looked upon NARST and other similar organizations as a means of self-aggrandizement or for largely mercenary ends, and when the organizations no longer served their purposes, dropped their membership altogether despite a very nominal membership fee. Thus they refuse to lend their support, professional, moral, or financial, to the organizations whose primary purpose is improving the teaching of science at all levels. As one NARST said to the writer "Such so-called leaders wouldn't walk across the street to attend a professional meeting unless they were paid financially to do so, or had their expenses paid, or could in some way profit from it personally. They never expend their time or energies in committee work or in other gratis science education activities." Almost without exception those who have dropped NARST membership have given as a reason that they could not afford the exorbitant yearly dues, now seven dollars. Not so Dr. Eikenberry, who even at an advanced age, has a standard of professional zeal, loyalty, and interest to be emulated by all of us who follow. In some ways it would seem, for reasons difficult if not impossible to fathom, this same professional interest has never been kindled in many panty-wasted science education "leaders." We need more science educational leaders with the same high standards of professional enthusiasm and attitudes as exemplified by Eikenberry, Caldwell, Whitman, Downing, Hunter, Underhill, Hurd, Powers, Curtis, Webb, Glenn, Palmer, Craig, Riedel, Jean, Gruenberg, Haupt, Ira Davis, and others. Some of our younger NARST members have caught this spirit, but the numbers are disheartingly smaller than they should be. The burden of promoting science education research is being carried by far too small a number of individuals. The field is wide-open and the opportunities rich for those who are willing to give of their energy, time, and to a limited extent, their financial and professional support.

Thus to Dr. William L. Eikenberry is appropriately made the Second Science Education Recognition Award.

Clarence M. Pruitt

ESSAY TESTING IN BIOLOGICAL SCIENCE AS A MEANS FOR SUPPLEMENTING TRAINING IN WRITING SKILLS *

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Introduction. One of the basic problems in education is to provide adequate training in communication skills. The job of providing this instruction at the college level has rested mainly with departments of English and/or departments organized specifically for this purpose. However, due to the significance of language in the acquisition of knowledge and in thinking and due to our present understanding of the transfer of knowledge, it seems reasonable to assume that every department should be cognizant of the need for training in communication

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skills and should attempt to provide opportunities within their own programs for continued instruction in such skills.

It is recognized that the problems associated with this latter proposal are complex and that there are differences of opinion as to the responsibilities of teachers and as to what they can be expected to do with large numbers of students in a limited time. However, it is also recognized that there is a real need for implementing this proposal and that it is desirable to set learning situations which will provide such opportunities. Such procedures as the small group discussion plan, panel discussions, and essay tests have possibilities for giving students experiences in developing specific communication skills. These techniques are cited because they are types of activities which could be carried on within the normal framework of almost any course. In fact, such procedures have been used by many teachers in various subject matter areas. However, even amongst teachers who have used such techniques, there are differences of opinion as to their respective values. This condition emphasizes the point of view that teachers should continually re-examine their beliefs in light of the actual situations at a given time and place and in regards to the overall objectives which are held for the entire education program. It was with this point of view in mind that the present study was undertaken.

Purposes and Design of the Study. The purposes of this study were: to ascertain the feasibility of short essay tests as one means for training in writing skills; to determine student achievement with respect to these skills; and to secure student reaction to this method (essay testing) of evaluation in a course in biological science.

The study was conducted in the Department of Biological Science in the Basic College at Michigan State College during the fall term of 1949. The students involved in the investigation were third term freshmen who had completed the first two terms in both Biological Science and in Written and Spoken English, a required course offered by the Department of Written and Spoken English of the Basic College. This latter condition meant that the students had had that part of the course in Written and Spoken English which was devoted largely to writing skills. Thus, the present study afforded a situation in which it was possible to further supplement such training. It is to be noted that the purposes of the study, its design, and the nature of the tests to be used were discussed with the students by the instructor. While the students did not make a choice as to whether or not such a study would be carried on, they were aware that an investigation was being attempted.

The special features of the investigation were:

1. The students were given during the first week of the term an essay test as a pre-test and they were administered the same test the last week of the term as a post-test.

2. The teaching assignment was such that the senior author had all the students in this study in both lecture and laboratory work. All students attended the same lectures and they constituted six separate laboratory sections.

3. The students in three of the laboratory sections were arbitrarily designated as group A and the students in the three remaining sections were called group B. Complete data were available at the end of the term's work on forty-four students in group A and forty-five students in group B.

4. The students in group A were given weekly essay tests for four weeks beginning the second week of the term and extending through the fifth week of the term. Students in group B were given objective tests during this same period.

5. The sixth week of the term the students in both groups were required to write an essay on the subject of "Enzymes."

6. Beginning with the seventh week and extending through the tenth week of the term, students in group B were given weekly essay tests while the students in group A were given objective type tests each week.

Materials and Methods. The instrument used as the pre- and post-test follows.

TABLE I

Streams	Temperature	Oxygen Content
Fast stream	50° F.	5 parts per million
Slow stream	85° F.	3 parts per million

Instructions

Read the materials in Parts I and II and study the accompanying tables. Write two papers in which you present your observations and conclusions or hypothesis for each of the situations. Bear in mind that your approach and treatment should be in keeping with that of a scientist presenting similar material. Do not ask for help in the interpretation of any of the tables. When completed, hand in your paper at the front of the room.

An Assignment

Imagine a situation wherein you were engaged by a gifted writer to accompany him on a tour of the states and act as an adviser and assistant in the preparation of articles of biological interest. Although the writer had no training in the techniques of the scientific method, he possessed an unusual capacity for discovering situations in nature which demanded biological explanation and interpretation. Your job was to relate the facts in these situations, point out the basic principles inherent in each and wherever possible show the relationships which existed between them.

PART I

During one excursion into rugged country the author, an amateur fisherman, spent considerable time photographing portions of two nearby streams. He had observed that the fish in the fast moving stream, which had a rocky bottom, were different from those in the slower moving stream. This you verified by examining his catch of fish which included trout, bass, and bullheads. However, it became apparent from his comments that he had erroneously accounted for the difference in the species distribution because he believed the fish understood their needs and made a voluntary choice. You had other ideas. As you obtained samples of water for oxygen and temperature tests your companion became inquisitive. In response to his interrogations you simply explained it was all part of a scientist's job and incidentally your assignment.

The following two tables may serve as the basis for your article.

TABLE II

Fish	Maximum Temperature Tolerance	Oxygen Content	Minimum Oxygen Toleration of These Fish
Trout	70° F.	4 parts per million	4 parts per million
Bass	85° F.	3 parts per million	1.5 parts per million
Bullheads	85° F.	3 parts per million	.5 parts per million

PART II

On a subsequent extended trip into the mountains, the writer as well as yourself experienced numerous distressing symptoms such as shortness of breath, cold, intestinal cramps and headache. As you expected, these did not come about without comment from the writer. He remarked that the climb, 14,000 feet above sea level, had probably been too rapid and vigorous and that relief would come with a few hours rest. You knew otherwise but abstained from commenting.

Unknown to your companion you had managed to make certain tests at various altitudes during the journey. You were very anxious to verify the information you already possessed. Among the tests you performed were hemoglobin determinations, barometric readings and respiratory rate counts. In addition, from tests on squirrels collected at various levels, it became apparent that animals are also affected by changes in altitude. All this data coincided very closely with certain published reports which you had taken the precautions to carry on the trip.

As soon as it was convenient you prepared an article, incorporating information obtained from the following tables. In this paper, you carefully presented the facts which were the basis for your hypotheses and principles.

TABLE I

Altitude	Number of Red Blood Cells	Per Cent Hemoglobin	Per Cent Oxygen	Mm. Hg.
Sea level	4.5–5.4 million	100	20.96	760
6,000 feet	5.5–6.3 million	110	16.60	602
14,000 feet	6.0–8.2 million	144	12.28	444

TABLE II

Altitude	Sitting	Standing	After Exercise
Sea level	72	72	84
7,000 feet	72	74	96
14,300 feet	72	84	108
16,500 feet	72	96	120
21,000 feet	108	120	144

TABLE III

Altitude	Days After Arrival	Volume Depth of Breathing
Sea level	100+	100
6,000 feet	1st	108
	3rd	115
14,000 feet	1st	125
	3rd	129
	20th	148
	35th	154
6,000 feet	1st	138
	3rd	121
Sea level	1st	111
	5th	100

Additional Information

1. Some writers have reported changes in breathing rate as low as 4,000 feet. Others report no change until 15,000 feet was reached.
2. The ten most commonly observed symptoms in order of frequency are as follows: (1) shortness of breath on exertion and easy fatigability, (2) breathing irregularities, (3) cold extremities, (4) dry skin, (5) disturbed sleep, (6) gas in intestines, (7) headache, (8) sore throat, (9) irregular pulse, and (10) lassitude.

This instrument was developed around subject matter which had been presented in the first term's work in Biological Science and none of this material appeared again in the content of the third term's work. As indicated in the test, the student was instructed to write two short essays in light of definite situations and of specific data. The students were expected to interpret such data with respect to a given problem situation and to draw hypotheses much as would a scientist presenting such materials in a report or paper. Each administration of this test was given in the lecture situation with approximately fifty minutes being available for completing the essays.

As mentioned previously under the special features of this study, the students in group A were given weekly essay tests for four weeks and during this time the students in group B were given weekly objective tests. Then the sixth week of the term the students in both groups were required to write an essay on "Enzymes." These essays were written during the laboratory period with approximately thirty minutes being allowed for this activity. The directive for this essay was as follows.

> Write a popular essay on the subject of enzymes. Use any of the following topics for content material: importance, relation to biochemistry of cells, properties, abundance, relation to respiration, digestion or metabolism, specificity of enzymes, species differences, relation to plants, enzyme research, or relation to life.

Beginning with the seventh week of the term the testing procedure was reversed with the students in group B taking weekly essay tests for four weeks and the students in group A having weekly objective tests during the same period. Thus, the students in both groups were provided with essay questions as one means for evaluating their work in Biological Science during the term and also as a means for training in writing. It is to be noted that group B was the control group with respect to essay testing the first half of the term and that group A was the control group the last half of the term.

The weekly essay tests were given in the laboratory situation and approximately fifteen minutes was allowed for each test. The instructions regarding each essay were placed on the blackboard. The questions were based as a rule, on materials covered the previous week in both lecture and laboratory assignments. Each essay was graded by the biological science instructor with respect to grammatical conventions, effective sentence structure, diction, organization, and content according to the directives in the "Minimum Essentials of Writing" as established by the Department of Written and Spoken English. Each was returned to students at the beginning of the next laboratory period with corrections and comments. Thus, it was possible for the students to examine their previous essay test just prior to their taking the essay test for that week. The students had

been given at the beginning of the second laboratory period a mimeographed sheet of the "Minimum Essentials of Writing" so that they might be aware of this aspect of the grading procedure.

The essay tests given to the students in group A were:

1. Recall three significant genetic concepts. Explain how each is derived by describing the facts or situations which support their validity.
2. Write a comprehensive description of the biological expression "Biotic Potential." Discuss its relationship to population, environmental resistance, and survival.
3. Prepare a paper of approximately 200 words on the subject of "Food Chains." Assume that this article is to appear in a newspaper column. Choose a title and develop each idea in paragraph form. Include an introduction and a conclusion.
4. (Diagram of a cross-section of a mountain.) Analyze the above geologic formations and index fossils and supply an hypothesis which would account for the inconsistencies in this frontal cross-section of a mountain. Incorporate your solution in an essay in which you discuss the geologic and evolutionary changes that may be inferred from this formation.

The essay tests administered to the students in group B were:

1. Recall three significant ecological concepts. Explain how each is derived by describing the facts or situations which support their validity.
2. Write a descriptive essay on the subject "Immunity."
3. Write a paper of approximately 200 words on the subject of "Prevention and Control of Disease." Assume that this article is to appear in a newspaper column. Choose a title. Develop each idea in paragraph form. Include an introduction and a conclusions.
4. (Table-Fox Population Studies for Years 1886 to 1890.) Study the following table of fox populations. Derive as many biological principles and hypotheses (inferences) as possible and explain each by presenting the facts which support them. Write a 200 word article based on the table. Use an introduction and conclusion. Employ paragraph development.

Treatment of Data, Results and Tentative Conclusions. Student scores on the pre- and post-test instrument were used to determine achievement with respect to certain writing skills. The scoring of the papers from both the pre- and post-test situation was secured in the following manner. The papers were coded and then graded by a member of the Department of Written and Spoken English. The same person graded all of the papers and he was unaware as to which papers were from the pre- or the post-test situation. The papers were marked with respect to grammar conventions, sentence structure, diction and organization on a forty point scale with ten points being the highest possible score for any of the aspects of the test. It is to be noted that the scores on this instrument were not used for grading students in the biological science course, but for the purpose stated above.

The t-test was used to determine whether or not the students in their respective groups showed any significant differences between pre- and post-test scores. In the case of the students in group A, there was a mean gain of approximately 1, but this was not significant. Students in group B showed a mean gain of 2.08 and this indicated significance at the 1 per cent level of confidence. Comparisons between the scores of the students in groups A and B with respect to the pre- and post-test by the same technique revealed no significant differences between the two groups at either administration of this instrument.

The "Enzyme" essay was also marked by the same grader with respect to grammar conventions, sentence structure, diction, and organization. A comparison of the scores of the students in groups A and B on this essay by use of the t-test showed no significant difference between the two groups.

From these findings, it seems reasonable to conclude that (1) the students in groups A and B did not differ significantly with respect to writing skills at the start of the study, at the time the testing procedure was reversed, or at the end of the study; (2) a small amount of training in essay testing, in this case four exercises in essay writing, did not produce any significant

improvement of one group over the other group; and, (3) the essay testing experiences were worth-while with respect to training in writing skills as the means for both groups were higher for the post-test than for the pre-test. It is interesting to note that recency of training may have been a factor favoring the students in group B since they were given the essay testing last and they showed the greater gain between pre-test and post-test. It should also be pointed out that the experimental design of the study could have perhaps been improved by using the pre-test instead of the "Enzyme" essay for measuring writing skills at the time the testing procedure was reversed.

Reported Student Reaction. In order to secure student reaction to the course in biological science and to the methods of testing which had been used during the term, a free response type of questionnaire was given to all of the students the last week of the term. The questions employed in the questionnaire with an analysis of the reported student reaction follows.

Question 1. Do you favor the use of both essay and objective tests in biological science? Eighty-three per cent responded favorably to this question.

Question 2. Which type of test do you prefer? Fifty-six per cent of the students preferred the essay tests with forty-four per cent favoring objective tests.

Question 3. Has the use of essay tests altered your attitude toward biological science in any way? Fifty-four per cent of the students indicated that they felt that the essay testing had produced some changes in their attitudes toward biological science. Some of the affirmative responses to this item were: "They have made me feel more sure of myself in discussing biological principles"; "I feel that the subjects written about were better learned as a more complete study was necessary . . ."; "Instead of important facts being my only interest, it has helped me to link my work with my everyday life"; "In putting my thoughts into words it has given me a higher respect for the subject"; "I have developed a much greater interest in biological science thru the use of the essay type exams . . ."; "The use of essay tests has helped me a great deal in understanding the overall picture of the subject matter rather than just memorizing a bunch of facts and figures."

Eight per cent failed to answer the item, three per cent indicated change of attitude which was unfavorable to the course, and thirty-five per cent felt that the testing program had produced no change in their attitude toward the course.

Question 4. Comments on either objective or essay tests. An analysis of these comments with respect to student reported reaction to essay testing indicated that 70 per cent of the students favored some use of essay testing. In general, these comments indicated that the students felt that essay testing provided opportunities for self-expression, for improving writing skills, for developing concepts, for reasoning, and for a better understanding of biological science subject matter. From the comments of the 30 per cent who responded unfavorably toward essay testing, one could infer that these students felt that such tests did not cover subject matter areas as thoroughly as objective tests and that they discriminated against students who were poor in writing skills.

Summary. In view of the need for continued experiences in writing skills, this study attempted to gather data with respect to the feasibility of using essay tests as one means toward providing opportunities for such training. The subjects were the students who were enrolled in the senior author's sections in the third term's work of biological science in the Basic College, Michigan State College. The students were arbitrarily designated according to laboratory sections as belonging either to group A or group B. The design of the study was such that the students in group A were given short weekly essay tests for four consecutive weeks with the students in group B taking objective tests during the same period. The testing procedure

was then reversed with the students in group B taking essay tests for four weeks and the students in group A receiving objective tests. The scores of the students on both types of tests were used in determining the instructor's evaluation of their work throughout the term. An essay type test was used at the beginning of the term to ascertain initial student achievement in writing skills and the same test was used as a post-test at the end of the term. An essay test was also given to the student in both groups the week prior to the reversal of the testing program which was followed in this study.

The tentative conclusions and/or educational implications of this study are as follows.

1. Short essay testing can be one means for the improvement of writing skills. This conclusion is supported by the finding that the mean score of the students in both groups was higher on the post-test than on the pre-test with the mean difference in one group being significant at the 1 per cent level of confidence. However, it is to be noted that within the controlled situations four exercises in essay testing did not produce any significant difference with respect to writing skills between the students having the training and those not having the training. Thus, the need for studies of longer duration is indicated by this finding.

2. Students favored the use of both essay and objective tests in the evaluation of their work in biological science. From the reported responses of the students with respect to the values of short essay testing, it seems reasonable to infer that the students thought that the essay testing had influenced their methods of study and that they believed that such testing provided opportunities for self-expression and for the expression of some of the aspects of critical thinking that are not provided for in objective tests.

3. In addition to the purported values associated with essay tests for evaluating student achievement in a subject matter area, the overall results of this study indicate both the desirability and feasibility of using short essay tests as one means for providing students with opportunities for continued training in writing skills. However, in order to provide this kind of supplementation, it should be emphasized that a great deal of time and energy is required to adequately grade essays and therefore due cognizance of this should be taken into consideration with respect to teacher load whenever such a method is employed for the purpose of improving writing skills. In connection with this point, it seems pertinent and significant to add that the use of essay testing without an awareness of certain desired objectives might conceivably result in poorer writing rather than in the improvement of writing skills.

NOTICE

Readers of *Science Education* knowing of mnemonic aids (aids to memory) in chemistry are requested to send them to

Professor Will Scott DeLoach
Department of Chemistry
Catawba College
Salisbury, North Carolina

References to such aids (magazines or books) will also be appreciated by Professor DeLoach.

NARST MEETING

The 1957 annual meeting of NARST will be held at the Hotel Claridge, Atlantic City, New Jersey, February 15–17. Remember to make your hotel reservation as early as possible through

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A BRIEF FOR A SOCIO-BIOLOGICAL SCIENCE COURSE IN COLLEGE GENERAL EDUCATION *

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1. INTRODUCTION

MANY writers have attempted to interpret the complex patchwork that is American education [1]. They have drawn attention to numerous and diverse forms of formal education. Today, certain educators claim that education for youth should be strict and disciplinary, like the education which was so common in early years of this country. Then there are claims that formal education should be more liberal, and should place greater freedom of choice and decision in the hands of youth.

There are those who claim that educational pursuits should perpetuate "culture." They hold that education should be liberal and should concentrate on the finer things of life which can be found in art, literature, poetry and the like. Still other claimants say that modern education should be generally introductory to all areas of man's knowledge and should foster free and intelligent exchange of ideas and views by all students.

Therefore, there are many diverse interpretations pertaining to the purpose of education, the content of education, and the value of formal educational efforts, which are recorded in various studies of education in this country [2]. These studies have led to experiments with interlocking and overlapping forms of specialized and liberal education. The most successful efforts have been developed most generally in the high school years and other pre-college years of the educative process in formalized educational institutions [3]. However, such "grass root" efforts for revised treatment of man's socially inherited information are complemented today by a general education movement at the college level in many large institutions.

Many innovations and experiments have been developed at the college level as attempts to meet criticisms of higher education under the free elective system, and as reactions to over emphasis upon specialization in colleges. These changes led to emphasis upon the adjustment of work to the individual and substitution of "field of concentration" for a "major" subject. These changes have, as a common purpose, redefinition of liberal education for the present age. Collectively, these changes are called general education.

"General education" is the term that has come to be accepted for those phases of non-specialized and non-vocationalized learning which should be the common experience of all educated men and women [4].

The philosophy back of general education calls for an effort to frame the educative process in terms of problems of life as men face them; that is, to aim the curriculum at human orientation and social direction. In other words, proponents of this movement propose to collect those essential parts of man's intellectual heritage that are deemed useful and meaningful for citizenship. Then, such essentials should comprise the content of the general education movement. It is believed that by such an approach the educational institutions will provide means for developing understandings of, and loyalties and devotions to democracy.

* Contribution No. 77 from the Department of Natural Science, Michigan State University. Based on the author's doctoral disseration, *Some Possible Derivations from Experimental Philosophy for the Teaching of Natural Science in College General Education Programs*, completed for the Doctor of Education degree at Michigan State University, August, 1952, and on a paper presented at the Twenty-Sixth Annual Meeting of The National Association for Research in Science Teaching, Atlantic City, New Jersey, February 16, 1953.

2. science teaching

From the above it may be taken that the primary function of education is the induction of youth into the commonly accepted ways of society. Then it would seem that educational institutions are mediating agents between society and youth. As a logical outgrowth of this general proposition, it would be consistent to recognize that science courses also are mediating agents in today's culture. Science classwork transmits understanding and knowledge about a restricted, narrowly identified field.

During the past few hundred years science and scientists have risen to a position of authority in modern culture. As this has come about, a dogma of scientific materialism also has developed. This dogma as practiced and utilized by scientists has given impetus to development of most of the so-called comforts of modern living. Also, as these fruits of scientific endeavor came into existence, a particular characteristic, specialization, developed in science and modern society. This specialization has come to dominate the social economy. At the same time the mentality of scientific specialism has neglected its social role, generally, by disassociating itself from general social conditions and giving exclusive attention to its own claims. Scientists have become established in a position where they are members of society, and yet, in some respects are not responsible members. Their special mentality has neglected its social role. Scientists have encouraged development of an attitude of "exclusive authority" to such an extent that they have attained a status in which they are wont to maintain themselves independent in an interdependent scheme of things.

Especially teachers of introductory science courses in the traditional educational institutions may be considered as contributors to an isolation of classroom learnings from the ways of living when particular attention is given to the effect, in education, of specialization. The present educational program in the sciences is splintered in the same way that all areas of man's knowledge have been subdivided. Therefore, the narrow outlook of specialization is common to the majority of courses in undergraduate programs in science and even extends into secondary educational programs.

The graduate training attitude which emphasizes advanced specialization suggests the conclusion that science specialists teach according to the tacit assumption that all students in science courses are apprentices to high level graduate endeavor. It is possible to consider that science specialists (including science teachers) show a group acceptance of the attitude and methods which seem to belong to scientific endeavor. Therefore, one might say that science specialists represent an association of people with like interests. In one sense it is possible to say that scientists are working together toward furtherance of their special interests.

In the formal educational institution, this amounts to stipulation of professional requirements. Because of extension of specialization and the graduate training attitude in secondary and college levels, these professional requirements are imposed upon students who take most science courses. Essentially, then, it is maintained here that science teachers (as association members) direct the application and fulfillment of professional requirements while operating as if all students are apprentices for like membership in an association of scientists. Therefore, science teachers in most introductory college courses seem to construct and teach science courses for their private interests, namely the preparation of new specialists. It would seem, then, that science curricula are not conceived primarily as stepping stones toward participation in an educative process which will provide "means for developing understandings of, and loyalties and devotion to democracy."

Upon careful study of the traditional educational situation referred to above, it is possible to detect a threefold authority

relationship in the classroom. There is the person of expert authority, the teacher; there is the subject of the authority, the student; and there is the field of authority which the teacher represents. In the area of the sciences, the science teacher is the bearer of authority. This claim for the attention of the student rests upon his superior knowledge and skill in the theory and practice of science as a specialized area of knowledge. Inherent in the situation is the supposition that the student, as subject of the authority, needs to gain a mastery of scientific techniques in order to function as a citizen of society.

Therefore, the science teacher personifies the field of science specialists as such. The purpose of the authority relationship with the student appears to be that of inducting or involving the student in the common skills, knowledge and orientation of the narrow association which the teacher represents, namely the association of scientists. This means that, in the authority relationship, the expert does not represent society, but represents the science association which constitutes only a narrow area within the potential societal association.

The net result of the above is the guarding of a so-called traditional approach to the treatment of subject matter and method of science courses. Consequently, past practices take on values which are usually not directed toward actual applicability of subject matter to the current social scene and youth of new generations. Taken collectively, these phenomena result in the existence of an isolated group of highly specialized individuals who are functioning for satisfaction of aims and objectives which might be assigned to a large association of such science individuals.

Now, it must be kept in mind that the stipulated purpose of education is induction of youth into the ways of society. This does not mean in the area of science that all students taking science courses will be desirous of introduction into the areas and ways of the so-called science association. Also, it must be stated that the field of authority of the traditional science teacher involves an expertness more in the factual-mechanical aspects of science rather than in the function of science from social and moral aspects. Thus, in actual practice the functioning of the authority relation fails to result in an extension of common skills, knowledge and orientation which are socially centered. Though the science teacher is presumably aiming at a use of subject matter in social living, it does not seem that this aim is to be accomplished through involvement of the student in the field of authority of the science teacher.

In other words, the general subject of authority in the science classroom is much like the patient who goes to a medical authority for treatment. In this case, successful consummation of such an authority relation does not, in general, eventuate in an extension of common skills, knowledge and orientation. If the doctor is successful, the patient ceases to be a patient, but does not become a doctor. Therefore, it should be clear that the subject does not become particularly involved in the field of authority. However, based on the authority relationship which science teachers of the traditional educational situation have with their students, it may be concluded that the actual consequent of the authority of science educators shows a striking parallel to the case of physician and medical student. The medical student is inducted into the field of common codes, rules and commitments which are identified with the expert who functions as a member of a professional association. Is this the situation that seems to be in order for general education students?

3. SOME PSYCHOLOGICAL CONSIDERATIONS

It would seem that particular conceptualizations of mind and learning are implicit to the conditions which have just been described. Apparently, in authority relationships mind is conceived merely as the total of all ideas and impressions which enter into one's consciousness during a single lifetime. Such a position seems to

be based upon associational psychology. Associational psychologists view human behavior as the result of the combination of atomic sensations or simple reflexes. The various types of associationalism

> . . . have tended to base themselves on a realistic and atomistic metaphysics, to insist that knowledge has its origin in experience, and to employ the method of analysis, that is, to reduce behavior to simple elements. In education this philosophy . . . has emphasized external control, habit formation and subject matter [5].

Therefore, it is easy to realize that associationalism has been an important doctrine to those who have sought a mechanical or physiological explanation of learning. It is not surprising, then, that the teaching methods of science teachers should reflect this viewpoint toward learning. Basis for this would be scientists' marked belief in and formation of research projects in science on the rather exclusive basis of scientific materialism.

Associationalism considers that learning is the active assimilation of ideas. Ideas or "presentations" are interpreted as grouping themselves into so-called "apperceptive masses" according to similarities among them. Then, new experiences are interpreted in terms of the old. This understanding of the new by means of the old has been called "apperception." Thus knowledge is built up in the mind by way of a series of steps.

Such a formulation would necessarily influence method. Various steps of the method have been presented but included the following, principally: (1) preparation, (2) presentation, (3) comparison and abstraction, (4) generalization, and (5) application. Although these once famous Herbartian formal steps are nearly forgotten per se, they did suggest a problem solving technique for teaching. This method became particularly appropriate to teaching in situations where books were central and ideas, as ideas, were taught.

However, the method is commonly misused. Often the burden of effort is carried by the teacher and not shared by the student in the learning situation. Because the method is general and because it is the method of inductive-deductive thinking in its complete form, it often is employed quite rigidly by teachers (among these many science teachers). Mind, characteristically expected to result from use of this method, is formed by the ideas impressed upon it from without, from the teacher and from books. Consequently, formalized education customarily has come to emphasize presentation of ideas. This seems to be the philosophical concept of mind and the psychological interpretations of learning which undergird the three-fold authority relationship in the traditional school situation as it has been described.

4. A contrasting orientation

It is possible that learning is more than development of an "apperceptive mass." Research and modern psychology justify the conclusion that active thinking tends in the direction of synthesis of ideas. An individual does not concentrate on isolated items of experience, but combines these items into integrated systems. This seems to suggest that general or introductory courses ought not concentrate upon learning of isolated facts [6]. Learning must be interpreted as more than recall of facts. Development of higher mental processes is also involved in learning. A higher mental process is one in which the individual makes a conscious contribution. Mere memory must be considered a low level mental process as compared to the degree of individual contribution when a person is comparing, inferring or abstracting.

In order to cultivate the higher mental processes of application of principles and use of inference, learning conditions appropriate for their cultivation are necessary [7]. It would seem that correction of an additive interpretation of learning is to be found in increased student participation in formal educative situations so that higher mental processes may be practiced. Then a more geometrical, progressional aspect of learning might be realized.

Mind. At this point some alternative concepts of mind and learning are in order. It is possible to identify mentality as a function within life processes of the individual. An explicit functional interpretation of mind stresses the idea that thinking is instrumental to the control of the environment; and, secondly, thought and mind are considered functional elements of a complex interaction of natural events. This concept of mind is directly or indirectly related to action. Therefore, judgments involve statement of the given facts of a situation so that an indication as to a course of action to pursue is revealed. This means that, through the activity of the individual, changes occur in the surrounding environment and new features arise. Thus, if the on-going activity of the individual is blocked, there arises a situation which can be characterized as being "doubtful" or "tensional." In such situations mind and consciousness arise. Mind as function serves the purpose of resolving doubt and tension so that the situation can be controlled and used by the individual to remove frustrated demands or interests. This viewpoint does not make mind and thought merely instrumental to nondirected random activity. On the contrary, specific interests of the individual are served. The conclusion should be clear that thought is inseparably linked with the demands of interested behavior; and, therefore, is instrumental to the satisfaction of certain demands.

The mechanism whereby the human being has gained control over his environment centers in the process of language communication. Language has provided a vehicle for indicating meaning to others *and* to the individual. This is an ability which gives particular power to the individual. The mind of the individual is dependent upon this mechanism of control over meaning. However, the mental processes do not lie in words any more than the intelligence of the individual lies in the elements of the central nervous system. Both are part and parcel of a complex process that is going on between the individual and the environment.

The complexity of this process whereby language assists the individual in controlling meanings about his environment, nevertheless, prevents the concept of mind from being exclusively individual. The conditions in which human beings have used the language mechanism for control over meaning are social situations. The isolated individual's experiences with his environment are not enough. Meanings arrived at through this limited means would not be as inclusive as the meanings which have been accumulated in man's culture. The individual gains a fuller experience through social acts.

In social situations the individual becomes aware of the relations of other individuals to the environment through the language mechanism. Therefore, the individual becomes self-conscious when he compares his meanings about the environment with those which others have gained. This self-consciousness leads the individual to make adjustments to the attitudes and ideas expressed by others in the social situation. This means that an individual's ideas become significant to him as he participates in the social process through the language mechanism. Others react to him and to his ideas. Therefore, the words and meanings which come from social intercourse, ideally, have greater significance to the individual than those obtained in isolated relation with his environment. In this way thinking is preparatory to social action.

If the social process is essential for the fullest development of mind, then individuals must, of necessity, be responsive and sensitive to one another's ideas and meanings. Mind is not to be considered as substance and is not to be located in the brain, as a storage house of facts. Mind is the functioning of significant meanings, but development of significant meanings and self-consciousness to the fullest extent depends upon the social process. This concept of mind is, therefore, alternative to that of mind as content only.

Subject Matter. From this conclusion, it would seem that subject matter in formal education would be the means for developing significant meanings. In other words, subject matter is that part of the educative process which furnishes the immediate environment. Subject matter stimulates responses and a course of action. Of course, subject matter may exist simply as knowledge. Often it may be studied for mere mastery of it irrespective of any social values. Interpretations such as these lead to a remoteness of subject matter from the experiences of youth which are quite real. Therefore, with the wide range of possible material from which to select, it is very important that the educational program, especially the program planned for beginning students, should be determined by use of a criterion of social worth. It is impossible to assume that all material is of equal value; thus, for general education students seeking a general introduction to science,

> . . . the curriculum must be planned with reference to placing essentials first, and refinements second. The things which are socially most fundamental, that is, which have to do with the experiences in which the widest group share, are the essentials. The things which represent the needs of specialized groups and technical pursuits are secondary [8].

Such a curriculum would be presented by way of social situations. It would involve problems relevant to living together. In working on the problems of living, observations and information would be worked out in a group process devised to develop social insight and interest. Of necessity, the curriculum could only be semi-structured to allow for variability of individual differences among students.

Now, what of science teaching and science courses in particular? In keeping with what has gone before, such courses would serve as media for the development of mind as function and would be vital parts of a curriculum calculated to result in social insight and concern. Science may be interpreted as representing a safeguard against certain human tendencies. Ordinarily, people like things undisturbed, settled and tend to treat them as such. They show a predeliction for premature acceptance and for assertion, and aversion to suspended judgment. They are satisfied with superficial and immediate short-visioned applications. Yet science is the safeguard against such practices.

> It consists of the special appliances and methods which the race has slowly worked out in order to conduct reflection under conditions whereby its procedures and results are tested. It is artificial (an acquired art), not spontaneous; learned not native. To this fact is due the unique, the invaluable place of science in education, and also dangers which threaten its right use. Without initiation into the scientific spirit, one is not in possession of the best tools which humanity has so far devised for effectively directed reflection. One in that case not merely conducts inquiry and learning without the use of instruments, but fails to understand the full meaning of knowledge, for he does not become acquainted with the traits that mark off opinion and ascent from authorized conviction [9].

Therefore, science is given a leading position in the mediation of culture from one generation to another.

Though scientific methods and procedures have much value, there is a grave problem for the education of youth if isolation and abstraction of subject matter should prevail in science instruction. The science courses in the curriculum also must be planned "with reference to placing essentials first, and refinements second." Those parts of science which are socially most fundamental and involve the experiences in which the widest group share are the essentials for the general education student. Consequently, students should be introduced to scientific subject matter and be initiated into its facts and laws through acquaintance with specific applications to societal living. In this way, the criterion of social worth may be served. Also, the development of significant meanings may be more assured. It is even possible that the instruction of youth in social applications of science will lead the way to measures and policies by means of which a better social order might be brought into existence.

Method. According to this viewpoint, the worth of school learnings is proved and substantiated by the degree to which those learnings actually merge with the social environment of youth. Certainly the inducting function of formal education involves, inherently, utilization of acquired information in the daily activities of youth. Therefore, method should emphasize utilization of information in the form of significant meanings for control of individual behavior and estimation of consequences of behavior in social situations. This utilization is what modern psychologists mean when they refer to transfer of information.

> By transfer is meant the operation (use or misuse) of learning in circumstances that are different to some extent from those under which the learning took place. . . . The utilization of that which was learned in one situation in reacting to or in learning to react to another situation is transfer [10].

General education courses should be conceived with enhancement of opportunity for transfer of information in mind. It would seem that education would be general in the degree to which social relationships are taken into account. If the student is concerned principally with technical subject matter, his action and his judgment may be ill-advised and inept outside of his specialty. However, if the student is concerned primarily with technical subject matter, which has been deliberately connected with human activities having social breadth, then the range of active responses called into play and flexibly integrated is much wider. Isolation of subject matter from the social context is the chief obstruction in current practice to securing general training.

No doubt it is a truism to say that the crux of the matter lies in the implementation of the educative process. Emphasis of formal education upon social use of intelligence and the fostering of variable viewpoints and opinions on the part of the educant suggests that implementation involves participation on the part of students and acceptance of individual responsibility in the educative process. Practice of the traditional educational relationship implements, directly, acquisition of facts and masses of information. Actually the give and take, approximation and correction, errors and repeated experiments, and so forth, of actual science work rarely creep into the awareness of youth being introduced to the portion of the community process which is scientific. So cut and dried is the form in which the information of typical science courses is presented that the "adventure" of discussion is left without trial. Nevertheless, this business of discussion is a large and very important part of the activities of scientists when in their laboratories. There, in the discussion phase of generating new hypotheses, creative aspects of the scientist's work come to attention. Yet what can be said for creativeness or the development of mind if opportunity for discussion is lost and exchange of student ideas and expressions is held to a minimum? It has been mentioned already that subject matter should be cast in a social environment. However, current practices of traditional science courses can hardly be interpreted as being conducive to such an environment when subject matter is taught in isolation from the community. This is so when classroom procedure isolates students from one another and from the teacher, who stands as an expert authority before the youth.

If transfer of information (ideas learned in one situation employed in a different yet related situation) is to be guaranteed as an end product of the educative process as practised in formalized educational institutions, then classroom methods must of necessity be brought into coincidence with certain methods practiced in the ways of life in the community. If there is to be a transfer of scientific information, it would seem quite logical that the information, in part at least, should be acquired through methods which would be utilized outside the isolation of the classroom. This seems to call for democratic methods in the classroom. Such methods would include stu-

dent participation, involvement, and concern and are very important to the concept of effectiveness of learning experiences being discussed. Both extensive student suggestions, as well as instructor suggestion, are involved here. Also included is the cooperative planning of the course or program of study and of the activities to be participated in by all in the presence of the entire group. This in no way means that the instructor should not direct or guide the planning into purposeful channels. All that is intended for emphasis here is the conclusion that social relationships which provide for face to face relationships are most desirable. Such situations are not the only possible social situations. However, in light of the interpretations developed above, the practice of encouraging student activity and creativity seems defensible. Nevertheless, the adult is still responsible to analyze the readiness of students for certain activities and to see that energies of youth are applied to worthwhile efforts.

Of course, concurrent with cooperative democratic action is the development of convictions on the part of students, individually, that the effort required to cooperate is worthwhile and pays dividends to the group and to each member of the group. To guide students toward realization of the value of cooperative effort requires logically that some considerable part of the class work be devoted to discussion, upon stimulation from the instructor, of what seems to be the worthwhile goals and ends at the moment for the individual student and his society. This calls forthrightly for opinions by all concerned about the democratic ideals and the common values which each member of the group holds for himself, singularly, and with other members of the group, conjointly. Thus, students should be guided to see that class work is more than competition between individuals.

5. Specific Alternatives

Role of the Expert. The expert in the general education program has a special mediating role in his relation to students who are mainly interested in gaining a general insight into, and understanding of, the field which the expert represents. He will be especially concerned that this expertness is available to students in such form and manner as will be applicable to the social field in which they live and have their being. To do this, the expert will not interpret mind as content only. He will interpret the phenomenon of mind as a process relationship of the student to environments to which he is sensitive. Such an expert will not fail to realize that vital student interest must grow out of personal needs. He will realize that growth and development of interests through the medium of formalized education involve a constant reconstruction and broadening of basic concerns of the individual (along with those of the instructor, for that matter).

The specialist will exercise his authority or expertness for purposes different from those which are implicit in the relation of patient to doctor or medical student to medical expert. The authority relation in these situations may be considered as two extreme poles on a continuum of authority relationships. The patient never becomes an intimate member of the medical assqciation. The medical student expects to be inducted into the medical association with all the common professional commitments and common information of an association member.

However, the authority relation of the science expert to the student in a general education program is located in some middle position on the continuum which separates patient from medical student. It is possible to consider the general education student as being involved in the field of science to an intermediate degree. The student, in a sense, asks that the science expert assist the student in developing or attaining social homeostasis on a level short of actual membership. If this be so, then the science expert must certainly utilize consistent and non-contradictory criteria as bases for inclusion or exclusion of subject matter. The expert must judge ma-

terial as to its contribution to the student's concept of himself or of the living world. In this modified authority relationship, the expert will help the student feel as an individual in mass education and will encourage democratic relationships.

The Learner. General education students are not apprentices to science association membership. These students are apprentices to citizenship in a democratically structured society. The purpose of the learner is to develop a character which will be fitting for life and continued participation in a democratic form of government. Thus the learner will recognize responsibilities to himself and to a group. For character of this nature to develop, the character of the learner will be three-fold. The learner will consider alternatives to his own ideas, will take a position as party to the group as well as recognizing himself as an individual, and will become an object of examination and revision, such that self-objectivity develops. The individual learner must be willing to participate in the classroom activities and to complete assignments given to him. He must be willing to participate in cooperative actions which lead to convictions and emergence of mind not only on his part, but also on the part of each individual member of the group.

Learning Situations. The central educational task is the development of character in people which will permit realization of social living. It would seem reasonable to expect that such characters would evolve from situations which call for democratic character. The following criteria might be used for selection of such situations:

(1) Situations must demand inspection of value orientations. Students must be faced with reasons for holding to certain personal values and the development of reasons for change in personal values. It would seem that practice in deliberation in confusing situations must be provided.

(2) Situations must stimulate personal commitments. Examination of personal evaluations and ideals will occur if different opinions are expressed. If a person is able to express his or her ideas and then hear ideas of others, there will be greater opportunity for increased personal integrity. A greater degree of self-objectification can result from these situations.

(3) Situations must demand extension of pertinent factual understandings. In modern complex society it is paramount that facts be learned so that new perspectives may be gained. Facts are evaluated in relation to past knowledge and past experiences and possibly lead to development of new understandings and new relationships. However, it is not sufficient that facts be learned alone. There should be a continual examination of the desired status of affairs such as to provide a future or on-going orientation for fact-finding. In other words, how do facts learned contribute to the acquisition of understandings and desired outlooks which may bring about the state of affairs that should occur? This is especially important in the great experiment that is democratic society.

Parallel to planning selection of situations, it is altogether important and necessary that evaluation of behavior and validation of objectives should be a part of the learning activity in the educative process. Evaluation should not just happen. It must be planned. Itemization of student objectives and instructor objectives should be a preliminary phase. Self-evaluation should be integral to any evaluation program. It would seem reasonable that pre-test and post-test results should be a part of the progress record of the education of any individual student. Attitude scales are very important. Mason has reported a successful attempt to employ the attitude scale as a directing agent to acquisition of attitudes as learnable facts [11]. His techniques can be expanded probably so as to point up to both instructor and to students the importance of attitudes. The attitudes that we hold toward our ideas and the attitudes of others are intimately involved in development of individual character.

6. NATURE OF THE FIELD

In general terms, the field or appropriate subject matter of a general education science course is the means or vehicle through which the expert, the learner, and the methods of the teaching-learning situation function. Science information is part of

the culture into which the learner is inducted. Of course, the general education student is not an apprentice to membership in the science association. Yet he is involved to a degree sufficient to gain some understanding about the field and the role of the association as part of the societal complex. It was stated earlier that social fundamentals are essential for general education students because they are the aspects that would be involved in development of the greatest number of individuals. Consequently, it is proposed here that the science curriculum should represent an attempt to fuse social, ethical, and moral generalizations with the commonly adopted fact-finding tendency of educational practices. Such a curriculum could provide for development of social insight and interest in science information. It is proposed as a means for reducing the isolation that is characteristic of teaching in traditional educational situations.

Such a proposal provides a potential integrated basis for the functioning of the science expert, the learner searching for a middle ground in the science field, and the kinds of teaching-learning situations which may be developed according to criteria mentioned above. It can be pointed out that the Church long ago carried out a social function of teaching beliefs and values which should be accepted and respected. Today, the State is responsible for education through all levels of government—national, state, county, town and village. Therefore, it would seem that a science course which has a field infused with social-ethical-moral principles, as well as factual content of strictly scientific concepts and principles, might very well be expected to help meet the exigencies of present day conditions involved in the substitution of secular teaching for sectarian training.

What does such a proposal do to the field content of a socio-biological science course in general education? What are the objectives of such a course? The latter question might profitably be approached first. The course discussed above would not dwell upon extensive coverage of specifics which might be required of an apprentice for association membership. On the contrary, broad generalizations of the biological sciences, with which ordinary citizens should be conversant, would comprise the course content. This means selection of science material which is useful in social situations. Furthermore, the material would be organized at the same level at which students would use information as members of society. Therefore, the general purpose or objective of a socio-biological science course in general education would be: *To assist students in utilizing specific knowledge of the biological sciences to increase their understanding of human behavior.*

Numerous lists of more extensive objectives are available [12, 13, 14]; yet the wording of such objectives is usually quite broad. Therefore, it becomes the responsibility of specially trained teachers to search out a means for implementing general objectives. This calls for a functional and operational method of denoting relationships of objectives to specific portions of the science course. Also, the process of planning implementation of objectives should involve participation on the part of general students and the science instructor.

Traditionally the instructor dictates what is important and significant without considering students' interests and needs. Of course, the instructor's opinion and experience is of value, and the instructor should have a definite say in what should be the main areas in a general education course. However, if the general education goals are important, and more than just lip service is given to some learning principles, certain basic assumptions should be recognized. Namely, (1) learning is facilitated and retention is greater when students help to locate and solve their problems in light of their interests and needs, (2) learning is facilitated by active participation in the learning activity, and (3) learning is primarily individual though dependent on direct or vicarious social intercourse. These assumptions point up the fact that

the individual student should be provided with learning situations in which he participates in forming and which are suitable to his interest, needs, capabilities, and experiences.

Therefore, it is suggested that, in cooperative teaching-learning situations, students and instructor might approach the problem of stating and implementing objectives of a socio-biological science course by comparing patterns of human behavioral phenomenon with some of the objectives listed by the President's Commission on Higher Education. It would be possible for the classroom group to cooperatively arrive at the following important ubiquitous phases of human behavior: (1) the tendencies of all men to think, develop a language, and communicate; (2) the tendencies of all men to live in a social unit and maintain a means of livelihood; (3) the tendencies of all men to recognize group action and identify natural laws; and (4) the tendencies of all men to search for explanations of unknowns and to develop codes of behavior and value systems into a philosophy of life. Then, with judicious direction by the instructor, it would be possible to guide students to see that these activities of all men are directly related to objectives of general education.

In detail, activities of man included under the heading communication and mental activity, i.e., thinking, inferring, abstracting, learning, may be related to the objectives, stated by the President's Commission, dealing with understanding the ideas of others along with effective expression of one's own ideas, and applying scientific attitudes and methods.

Secondly, activities of maintenance of life in social units of a family, clan, and the like, may be related to the objectives of maintaining health, and acquiring knowledge and attitudes necessary for participating in a satisfying family group.

Thirdly, activities of conservation of natural and human resources, study of group interaction and search for natural laws which explain events may be related to the objective of recognizing interdependencies of people and the need for cooperation.

Lastly, activities of explaining unknowns and developing codes of behavior and value systems into a philosophy of life may be related to objectives of obtaining satisfactory emotional and social adjustment, and developing a code of behavior based on ethical principles consistent with democratic ideals.

Thus, objectives of general education may be operationally defined. Students and instructor may derive a fuller meaning from the general terminology of the stated objectives. Also, by relating objectives to human behavior, the students may fuze such objectives with their own objectives. Then, in turn, these relationships would be utilized in social teaching-learning situations to relate the tendencies of all men to areas of the biological sciences (See Table I).

It must be repeated at this point that no completely structured course organization is possible here because of the various interpretations already made with regard to mind, method, and desired outcomes of individual development of students in a general education program. However, it is possible to give some suggestions of appropriate subject matter areas that might conceivably be derived through cooperative effort of students and instructors for purposeful study. In considering, in a general way, representative content of general education socio-biological science, four major areas will be discussed. (A paramount guide in development of a socio-biological science course would be the attempt to serve individual differences of students. All students might not choose the same problems for specific study, but they should expect to exchange their findings if possible.)

Communication. Communication is the keynote of the first area and involves a fundamental characteristic of the human being. This societal activity may be definitely correlated with scientific concepts and principles about irritability and nervous adjustments to the environment on the part of the living organism. Therefore, it would

TABLE I

A DEVICE TO RELATE BROAD OBJECTIVES TO SPECIFIC BIOLOGICAL SUBJECT MATTER

To understand the common *phenomena* in one's physical environment, to apply *habits* of scientific thought to both personal and civic *problems*, and to *appreciate* the *implication* of scientific discoveries for human welfare.

General Objectives from President's Commission	Human Behavioral Tendencies	Areas of Biological Science	Specific Subject Matter
To understand the *ideas* of others and to express one's own effectively. To acquire and use the skills and habits involved in *critical* and *constructive thinking.*	Communication	Nervous activity, learning	Irritability and nervous adjustment, learning, abstractions, symbols, attitudes, methods, study methods
To maintain and improve his own *health* and to cooperate actively and intelligently in solving community health problems. To acquire the knowledge and attitudes basic to a satisfying *family life.*	Maintenance	Self-study of growth and heredity	Human sexual reproduction, attitudes toward Mechanisms of heredity in human beings
To recognize the *interdependence* of the different peoples of the world and one's personal responsibility for fostering international understanding and peace.	Natural laws	Group-study, principles of ecology and populations	Ecological concepts of populations, conservation, concept of race
To attain a satisfactory *emotional* and *social adjustment.* To develop for the regulation of one's personal and civic life a *code of behavior* based on ethical principles consistent with democratic ideals.	Philosophy	Synthesis and explanations by theory of organic evolution	Brief ideas of geological change Animal and plant classification Organic evolution, competition vs. cooperation

be quite logical for study of human behavior in socio-biological science to become involved in examination of some of the anatomy of the nervous system. Other subproblems that might come out in studying man's acts of perceiving and adjusting to stimuli are: How does man learn? How does man perceive? What factors effect memory and forgetting? These activities have led to the great fund of knowledge which man possesses concerning his environment and himself. It is this tendency of all men for ideation and learning, a concept which involves the nervous system, which is offered as a logical and psychological beginning for a course formulated according to the orientation presented as alternative to traditional educational situations.

Another aspect of this area involves the study methods which students employ in their formalized educational work. These processes ought to be a focus of their attention while considering the learning process as a part of the emphasis on self-study and self-objectification. Such objectification of students' methods of learning should make fundamental contributions to the value of a science course in general education. This statement is based on the contention that awareness of some of the operative components of learning activity and study methods might influence advantageously

the academic performance of all youth participating in formalized educational experiences.

Maintenance. Pertaining to the second tendency grouping of man's responses and adjustments, the basic social unit and self-maintenance, there are many, many facts concerning an individual's growth. This area permits furtherance of self-study. It would be possible to start with a discussion of the dependency of the child on the mother, to go into considerations of childbirth, and the processes of healthful living as the individual grows and develops to adolescence and adulthood. Activity through discussions, panels, and individual reports should provide means for students to objectify, to themselves, some of their attitudes and dispositions toward human reproduction. Students are usually interested in inheritance of physical characteristics. The social scientific problems of inheritance of desirable and undesirable characteristics would be reasonable inclusions in this area. There could be discussion of social legislation for mental cases.

Natural Laws. Then after a consideration of the individual's growth and development, it is quite reasonable to study the tendencies of men to search for natural laws that explain events. In this area opportunity is provided for social orientation of the learner. As a result of man's ability to think and have ideas and ask questions he has come to control his environment and, to a lesser degree possibly, control himself. These thoughts lead to discussions of forms of life and their interrelationships and the control that is possible on the part of man through knowledge of natural laws. Ecological concepts and population dynamics are very important in this area. Thus the student may extend fact-finding activities by application of these generalizations to human behavior. The social scientific problems of soil conservation, stream side conservation, and international food distribution could be included here. Some of the greatest and most important problems of the community are the social scientific problems related to the concept of race. Any discussion of the concept of race is a very important stepping-stone into the fourth area of scientific philosophy.

Philosophy. The fourth large area of appropriate subject field for a socio-biological science course in general education would involve the tendency of all men to search for value systems or philosophies which are internally consistent, and which might be guides for daily behavior. The biological science course which involves social teaching-learning situations would contribute to development of an individual learner's philosophy of life and moral value system without explicit statement to that end.

In biological science, explanations of development of various forms of life on the earth and some interpretations of changes of the face of the earth are manifestations of this fourth behavior tendency of man. These explanations have been developed by scientists over the centuries to explain unknowns of the past and give them some relation to unknowns of the future. These explanations have been promulgated by scientists in keeping with their effort to formulate notions which have operational meaningfulness and predictive value. Discussion of these explanations would logically call for a selection of some specifics concerning organic evolution. It can be shown that this scientific theory directly influenced the social structure of the times during which it appeared. It also has affected subsequent modifications of man's societal arrangements.

Today, data of modern science experts are providing more and more support to the conclusion that too much emphasis was given to competition in organic evolution by scientists of the 19th Century, and not enough attention to cooperation. A study of the social scientific problem of competition and cooperation would lead to a more complete interpretation of the theory of organic evolution. Essentially, then, the

TABLE II

Summary of Relatedness of Man's Behavioral Tendencies, Appropriate Subject Areas, and Basic Values

Man's Behavioral Tendencies	Course Study Areas	Beliefs and Values of Culture
Communication	Nervous activity, learning	Scientific attitudes, rigor of thinking
Maintenance	Self-study of growth and heredity	Good health, eugenics
Natural laws	Group-study, principles of ecology and populations	Democracy
Philosophy	Synthesis and explanation by theory of organic evolution	Competition-cooperation, love and brotherhood

science expert, who works directly with general education students, may help implement the ethic which places primary value on the sacredness of truth. Their method is inherently democratic. They may help students develop insight into the trends of evolution toward a cooperative as well as a competitive life. Students in a socio-biological science course would gain understanding of material evidence which adds credence to the prophetic pronouncements of centuries ago. Also they may develop a concept of the tremendous "cosmic" experiment which has been continuing on the earth for eons of time. They should be able to recognize that man is on trial in that experiment for adaptability, like all other life forms.

7. Conclusion

A socio-biological science course in general education of an unstructured nature just described is considered as a partial answer to some conditions of modern secular education. Throughout such a course the group and individual activities already mentioned would be as important as the subject matter specifics of the biological sciences selected as aids to student understanding of human behavior. Also, through such a course which encompasses four large areas of human behavior, beliefs and values could be consciously introduced into the educative process, as they had been in medieval times when religious training was paramount in the societies of man. (See Table II.) By considering the social process as the appropriate subject field of a socio-biological science course in general education, the teaching-learning situations would contribute to guardianship of the "way of life" as part of the secular education which, in the present day, is intended as a substitute for sectarian training.

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THE EFFECT OF DIFFERENT LEARNING METHODS ON CONCEPT FORMATION *

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ONE of the major tasks that confront students in learning a science is the grasp of the many special concepts. Technical class names are particularly numerous in the biological sciences. Although psychologists have made many attempts to describe concept formation, much work is yet to be done in determining the most efficient methods of this type learning.

If we observe students in the act of learning class names, we can discern at least two gross differences in procedure. Some students seem to adopt a rote memorization method by repeating verbalizations of definitions and by memorizing discrete items of the various classes. Other students go about the task by attempting to identify common characteristics of class members to discover the underlying principles that differentiate classes. They observe, manipulate materials, and test hunches in order to formulate an understanding of concepts rather than committing to memory each specific instance.

Teachers seem to differ in the degree they utilize meaningful and functional ways of presenting concepts. The problem of identifying experimentally efficient modes of instruction is far from simple. The problem may be confounded by the possibility that some students operate more efficiently under one learning method while others fare best by using a different approach. If that is so, then efficient learning methods must be handled in terms of specific characteristics such as personality patterns, intellectual habits, special abilities, attitudes of both students and instructors.

The present study is an attempt to collect data bearing upon this question: What is the difference between a functional condition of concept learning and a rote condition when outcomes are measured in terms of retention and demonstration of a meaningful grasp of acquired concepts? Expressed as an experimental hypothesis, the question becomes: A functional condition of concept formation, emphasizing mean-

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ingful learning, results in greater retention of facts and understanding than concepts learned by rote. Although the answer to this question may appear obvious, specific evidence to support a generalized answer is needed.

Materials and Procedure

The Hanfmann-Kasanin or Vigotsky Block Test was used. Stimuli are small wooden forms that vary in size, shape, color, and height. Each block is a member of one of four classes designated by nonsense syllables, including "bik," "cev," "lag," and "mur." Class membership is determined by height and approximate size of top area. All "cevs" are short and small; "biks" are short and large; "lags" are tall and large; and "murs" are tall and small. Each block has its class name stamped on its base, and therefore the name is not visible in the normal position. These stimuli are widely used in psychological clinics in diagnosing and describing certain syndromes. Hanfmann and Kasanin [2] have described the test in detail.

Condition I (Functional). Ss were presented stimuli in the normal position on a flat surface about 30 inches high. They were randomly placed. A sample block of the "cev" and "mur" classes was turned upside down to expose the name. Ss were asked to select the remaining four members of each class. (The white hexagonal "cev" was not used.) In the course of one trial, S placed his selections near the sample blocks and was reinforced on 50 per cent of all correct choices. Trials continued until S has chosen all eight blocks without error in a single trial.

Condition II (Rote). The experimenter presented the same stimuli and proceeded to dominate S's attention by a continual line of verbal instruction. The experimenter told S that there were four classes but concern would be directed on only members of two classes, the "cevs" and "murs." The same sample blocks were used as in Condition I. Blocks were referred to in terms of color and shape of the top plane. S was informed that the "mur" class was composed of a white hexagon, a white circle, blue circle, yellow square, and yellow triangle. Similar terminology was used to identify members of the "cev" class. At no time did the experimenter mention blocks in terms of their defining characteristics, height and size. Instruction continued until the subject indicated that he could reproduce from memory the identity of each class member, using the same terminology contained in the instruction. In case S failed to list all blocks in each class correctly, the experimenter repeated, in essence, the same talk, which was punctuated with as many tests as necessary to achieve the learning criterion. During the memory test, the experimenter held a large cardboard panel over the blocks.

A post-test was given one week after the learning trials. With the labels of the two sample blocks exposed, S was asked to pick out the remaining members of each class under a two minute time limit. After he had made his selections, he was asked to state the defining characteristics of both "cevs" and "murs."

Results

1. Number Ss beginning and completing experiment:
   a. Group I (functional)
      (1) Beginning: 35
      (2) Completing: 31
   b. Group II (rote):
      (1) Beginning: 35
      (2) Completing: 28

2. Number of minutes to reach learning criterion:
   a. Group I (functional): 33.6 minutes
   b. Group II (rote): 6.8 minutes
      Difference significant at .001 P.

3. Number of correct identifications during post-test:
   a. Group I (functional): 24 or 77 per cent identified pieces without error.
   b. Group II (rote): 8 or 29 per cent

identified pieces without error.
Chi square = 8.0, significant at .01 P.

4. Number of correct verbal definitions of concepts:
   a. Group I (functional): 14 or approximately 52 per cent.
   b. Group II (rote): 3 or about 11 per cent.
   Difference significant at .01 P. Chi square = 7.09.

DISCUSSION

Several limitations of this study require recognition before tenable conclusions can be formulated:

1. Since the two groups were exposed to the learning process for unequal times, it is not clear whether the advantages of the functional group would be maintained had the exposure time been equal. A short follow-up study with 18 Ss were used to repeat the rote condition. When S had reached his learning criterion, ability to describe verbally class members from memory, instruction time continued until the original learning criterion time was doubled. Gains as a result of this over-exposure were not appreciable over the original rote group. During the overlearning period, Ss appeared restless and attention seemed to wane. Overlearning in this situation appeared to be a poor investment in time and energy.

2. The two minute time limit of the post-test probably served to increase anxiety and therefore lessen ability to recognize the correct blocks. If more time had been given, it is conceivable that the rote group would have performed more efficiently. But the same argument holds for the functional group. It cannot be concluded, therefore, without further experimentation, whether or not the speed post-test handicapped one group more than the other.

3. The fact that practice effect favored the functional group more than the rote group is a criticism that is cogent and perhaps damaging unless interpreted as an inclusion of a realistic condition. In most teaching methods experiments practice effect cannot be held constant. For example, in the lecture versus the discussion method the amount of practice varies enormously both within and between groups. Also, instructors are often guilty of teaching one thing and testing for something else. Students sometimes complain that test items are not a fair sample of reading and classroom experiences. This study helps substantiate such complaint. There seems to be little doubt that the fairest test of achievement must cover experiences of learning. If the instructor desires application as an objective, he should see to it that some practice in application is given in the course work. Otherwise, expectancy of growth in application is not well founded.

4. The independent variable was not composed of a single operation; rather, it was a complex of variables. In other words, the difference between the two situations cannot be neatly isolated as a single variable. Differences in conditions included the presence and absence of immediate reinforcement, more time exposure in one condition than the other, more practice effect in the functional condition, a greater similarity between learning experience and the post-test task for the functional group. Therefore, it is not possible to point to a single variable as responsible for the differences in performance. It is necessary to think of two complex conditions operating upon learning and differences in results accounted for in terms of operational complexes rather than the effect of a single variable. In virtually all teaching methods studies, however, control is not such that all but a single variable is systematically manipulated.

5. The oft-used criticism that studies of this type are artificial and therefore reflect little or nothing about real-life situations needs to be faced. As Festinger [2] reminds us, we should regard laboratory experiments as deliberate attempts to create "unreal" or artificial situations for the purpose of acquiring advantage in isolation of variables and the determination of their

relations. The present study, however, may appear to suffer from both artificiality and lack of control. Although this study does not allow one to point to a single variable as responsible for differences, it represents a tremendous reduction of complexity in contrast to the usual classroom. Ss were dealt with one at a time which reduced the effect of interaction found in classrooms. Hence, it is possible to say that student interaction during learning did not account for differences. The scope of possibilities, although still large, is reduced to something within the realm of manageability. The "lack-of-control" criticism is perhaps attenuated by the fact that the study was a deliberate attempt to work with complex variables in trying to ascertain the combined effect of a manageable set of operations on concept formation. In summary, this study stands about midway between the rigorously controlled single variable experiment and studies about comparison of classroom methods.

CONCLUSIONS

In light of results and methodological limitations, the following appear to be tenable generalizations:

1. Functional learning of concepts, as defined herein, is more efficient than rote learning when measured by retention and ability to verbalize meanings of learned concepts.

2. Concepts that refer to classes of material objects are more thoroughly understood when the student has an opportunity to manipulate and study the objects than when only factual information is given by lectures.

3. The problem of specificity does not prevent fruitful research of teaching methods. That is, the argument is sometimes heard that the learning process is so complex and sensitive to minute alterations in conditions that the only possible way of procedure is to describe completely the learner's personality, attitudes, aptitudes, habits in learning and particular task under an instructor, who has also been completely described. This study suggests that much worthwhile work can be done without submitting to complete specificity.

EDUCATIONAL IMPLICATIONS.

Several inferences from present results appear to be applicable to the teaching situation:

1. Lectures bereft of unifying explanations that include only discrete facts seem to determine the amount of inadequacy students will display on the level of application. Although this appears to be an educational truism, it serves to remind ourselves, as teachers, that transfer of learning cannot be handled by assumption but must be a definite part of training so long as application is a course objective.

2. Effective learning is not merely a function of practice but depends upon a complex of operations, including reinforcement, hypothesis construction and testing, exposure time, and set. When courses are planned that preclude the effect of one or more of these variables, it is reasonable to expect that optimum acquisition of functional knowledge will not be attained.

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EDUCATIONAL SIGNIFICANCE OF STUDIES ON THE RELATION BETWEEN RIGIDITY AND PROBLEM SOLVING

II. Educational Implications from Studies Based on the "Personality Approach"

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The purpose of this paper is to examine a number of studies conducted in the "personality approach" framework and to show the kinds of educational implications involved. This report ends with a critical evaluation, indicating some inherent advantages and limitations of rationale and methods contained in the personality approach.

The third and last paper will be a review of studies in rigidity undertaken from the learning position with a concluding section comparing the fruitfulness of the two methods in terms of educational implications. A study is said to have educational implications if: (1) the data suggest testable statements about educational concerns, and (2) the study itself is reasonably sound. This second condition is not too clear and it is one that may generate much disagreement among judges in the evaluation of particular studies. The writer decided to err on the side of laxness rather than apply severe criteria because the primary purpose is to determine what statements of educational significance are implied. On the other hand, if the error seems to be damaging to the study as a whole, it was decided to point it out and consider the accompanying implications as having doubtful support. An educational implication, then, will be taken to mean a testable hypothesis having some support by the study. Some of these implications will appear to have support on independent grounds. Others may seem platitudinous. But the criterion of inclusion is a logical connection between the study and educational statements. But the practical goodness of such logical connections is partly a function of the soundness of the methods and conclusions in the studies.

Meaning of Mental Rigidity. Unless otherwise specified rigidity will be used to mean the perseveration of habitual responses in a problem solving situation where a more efficient reaction is within the ability of the respondent.

As indicated in more detail in the first article of this series, the personality approach is characterized by an emphasis upon identifying traits that are said to be the basic components of behavior structure. Learning is largely determined by the effects of the dynamic relations that exist between traits. Therefore, in order to understand how an individual learns it is necessary to discover his unique pattern of personality. The most common methods of research used by protagonists of this approach are straight test correlations and factor analysis. However, the clinical study of personality involves interviewing, direct observation of behavior in a "natural" setting, psychoanalysis, anecdotal records, and sociograms.

The learning approach begins with the assumption that most behavior is learned (not inherited) and depends upon what happens to the person or on environmental conditions. Personality characteristics are said to be learned. Therefore, by determining the principles of learning, personality can be accounted for. The most common method of research is the experiment in which behavior changes are noted as a function in the variation of environmental conditions.

STUDIES IN RIGIDITY INVOLVING THE PERSONALITY APPROACH

Is rigidity a general personality trait? This question, more than any other, seems to have stimulated research in this methodological class. It is felt that persons found to be rigid will lack mental flexibility in most situations. Therefore, knowledge of rigidity scores should contribute to more effective educational and vocational guidance. Also, if psychotherapy is needed, rigidity typology may help the therapist prescribe more appropriate remediation.

Cowan and Thompson [3] attempted to collect evidence to help determine whether or not rigidity is a general response characteristic. They used a test made up of Luchins' water jar type problems and correlated results with the following measures: (1) Bell Adjustment Inventory, (2) California Test of Personality, and (3) the Rorschach Ink Blot Test. (The Luchins "Einstellung" Test is intended to measure resistance to shift to the simpler of two solutions of arithmetic problems after having been conditioned or set to use the complex solution.)

Results. (1) Regarding the Luchins type test as a measure of rigidity, they found the Bell and California tests failed to differentiate rigid and non-rigid Ss.

(2) But the Rorschach results had the following relations with "Einstellung" or rigidity scores:

(a) "Einstellung" Ss were less productive and imaginative than non-rigid Ss.
(b) "Einstellung" Ss were less able to see complex relations and make constructive integrations.
(c) "Einstellung" Ss were judged to have more emotional suppression than non-rigid Ss.
(d) Rigid Ss showed more hesitancy to accept experience having novel psychological meanings.
(e) Rigid Ss were more uncertain and lethargic.
(f) Rigid Ss had a more restricted range of interest.
(g) Rigid Ss were said to be more withdrawn
(h) Rigidity was accompanied by poor social adjustment.

Conclusion. Rigidity is a general personality factor.

It is difficult to agree entirely with the conclusion because there seems to be a number of arbitrary decisions involved that are open to question. In the first place, it was assumed that the "Einstellung" test is an adequate measure of rigidity. It is reasonable to suspect that while Ss may be rigid in Luchins' test they may be quite flexible in many other problem situations. We cannot assume that the test is an indication of global rigidity until it is validated. Secondly, it could be argued that since "Einstellung" scores had no significant correlation with the Bell and California tests that rigidity is *not* a general trait. Strict regard for the data does not seem to support the idea that rigidity is general.

Educational Implications. All statements from (2) (a) through (2) (h) can be regarded as interesting hypotheses to be put to further test. Therefore, the value of this study is more in terms of its hypothesis production than its provision of grounds to support any particular hypothesis. One or more doctor's dissertation could be written on any one of the eight statements under (2), above.

Rokeach [11] wanted to show that people having a high degree of social prejudice are intellectually rigid. Social prejudice was measured by the California Ethnocentrism Scale designed to elicit attitudes about zootsuiters, Negroes, Jews, and foreigners. Ten items composed the measure. To estimate intellectual or problem solving rigidity (exclusive of social problems) he used a modified version of Luchins' "Einstellung" Test. His definition of rigidity operationally amounted to the failure to adopt the simpler of two formulas after being set to use the complex formula. He interpreted his results to support the claim that intellectual rigidity and social prejudices are positively related.

There is some doubt concerning the tenability of his instruments and interpretations. Luchins [8], for example, who originated the "Einstellung" test, denies that "Einstel-

lung" behavior is the same as rigidity defined by Rokeach. (Rokeach [12] replied to Luchins' criticisms point by point.) Since both rigidity and prejudice were measured only in a very narrow sense, conclusions of the study are open to question.

Educational Implications. In spite of the doubt, this study suggests some interesting questions that need to be investigated. (1) Would learning to be more skillful in problem solving decrease the intensity of social prejudice?

(2) Would experience other than problem solving designed to decrease prejudice make students better fitted to tackle intellectual problems?

(3) Would Rokeach's results hold in a variety of subject matter areas?

(4) What prejudices are learned and perpetuated by school experience?

(5) Does the prejudice-rigidity relation remain relatively stable in different school environments, e.g., in the traditional and progressive schools?

Fisher [5] tried to determine whether rigidity is a general trait and whether normal Ss differ significantly from psychotics in rigid behavior. A number of tests were chosen to make up a battery of rigidity tests, including the Vigotsky Block Test, a color preference test, and three picture tests in which Ss were asked to make certain evaluations and comparisons between the pictured persons and themselves. One-third of Ss were classed as normal, one-third as paranoids, and one-third as hysterics. Total N was 60 and all were females.

A variety of comparisons were made between scores of the battery and such measures as rigidity by the Rorschach, the Guilford STDCR Test, the verbal section of the Wechsler-Bellevue, and the TAT. Results showed that most correlations were low, which was interpreted as evidence against rigidity as a general trait. But a number of questionable assumptions were made in using the various tests. Here is a sample:

(1) The color test amounted to getting the number of color preferences or favorable reactions to a variety of colored ribbons. It was assumed that the fewer the favorable reactions the greater the rigidity. This seems to lack plausibility when rigidity was defined as perseveration of inefficient responses in *problem solving.* There was little if any problem that S faced when asked to pick out the ribbons he preferred.

(2) In the first picture test Ss were asked to state whether or not the pictured person was friendly, ambitious, had a sense of humor, and the like. The experimenter assumed that the more restrictive and critical S was the more rigid he was. Again, this does not seem to place S in much of a problem situation. It would certainly seem that the study should begin by testing the assumption rather than regarding it as self evident. The assumption implies that 'criticalness of judgment' denotes rigidity. It is not clear what is meant by 'criticalness of judgment.' But if it is close to what is usually meant by critical thinking, there seems to be a divergence of terms. Critical thinking may or may not be stereotyped, depending upon the kind of problem and the condition of S. If the problem is completely novel where all past formules fail to work, then success seems to depend on flexibility. Since success is the criterion of problem solving, 'criticalness' may often prove to be the kind of behavior necessary to achieve success. Fisher failed to make clear how 'criticalness' would be related positively to rigidity.

(3) In the second picture test, S was told to judge whether the pictured person was in any way like S. Fisher assumed that the more similarities S found between himself and the photographed person the less rigid he was. It could be argued that rigidity in this test was a sign of intelligence, i.e., the more differentiations S could make the fewer similarities he was likely to report. Fisher's assumption could mean that the less able S is to make discriminations the more flexible he is. Of course, this is not plausible. Fisher must have

been thinking of something else, perhaps identification. He may have felt that the more a person tends to identify himself with others the less rigid he is. In any event, the most serious defect in the study is that Fisher proceeds as if he expects rigidity defined and measured in a variety of ways to somehow be identical. The various definitions of rigidity are not made explicit but they are implied by the operations and the special assumptions. There is little wonder that most of his correlations were low.

Educational Implications. Other similar assumptions were made. This multiplication weakens conclusions proportionately. Therefore, to expect that educational implications drawn from the conclusions gain in plausibility because of the great mass of data collected is to ignore the many weaknesses of the study. These considerations make the labor of drawing implications otiose.

Huber [7] hypothesizes that intellectual perseveration, concrete thinking, and rigidity of attitudes are not related significantly and therefore rigidity is not a generalized trait. To test his hypothesis he correlated the following measures: (1) A vocabulary test of 40 nouns designed to yield a measure of abstract-concrete thinking.

(2) The Beier revision of the Holsapple Test to measure abstract-concrete thinking with non-verbal material.

(3) A Cattell battery of four perseveration tests yielding a single score.

(4) Two Thurstone Attitude Scales to estimate crystallization of attitudes.

Results: (1) Verbal concrete thinking and perseveration were significantly related.

(2) Verbal and non-verbal concrete thinking were significantly related.

(3) I.Q. seemed to be related to all the other measured factors. *And when I.Q. was partialled out none of the r's were significantly greater than zero.*

(4) It seems probable that perseveration and lowered intellectual functioning are associated.

(5) Perseveration, concrete thinking, and attitude crystallization seem to be discrete concepts.

Educational Implications. Each of the above results can be regarded as a statement for further study. It would be worthwhile to see if other measures of perseveration would yield comparable results.

Pitcher and Chalmers [10] attacked the problem, as have many others, of determining whether or not rigidity is a general personality trait. Also, as have many others, they employed the test correlation technique. They used two instruments: (1) The Guilford-Zimmerman Temperament Survey, and (2) a verbal similarities test constructed by the authors.

The Guilford-Zimmerman Survey: This instrument is alleged to measure 10 personality traits: general activity, restraint, ascendance, sociability, emotional stability, objectivity, friendliness, thoughtfulness, personal relations, and masculinity. The total survey contains 300 items or 30 items for each trait. Traits were determined by factor analysis. S has the task of rating himself on the basis of "yes," "no" or "?" for each item. A high score is in the direction of the socially desirable end of each scale. Reliability coefficients of the various subtests range between .75 and .85.

Verbal similarities test: The authors wanted to get a different measure of "Einstellung" than provided by Luchins' Test, which has already been used repeatedly. Each item was composed of three words. S was asked to tell how the three words were alike or the same. Three set items were given as examples in which the answers were all functional in nature, i.e., all objects could be used in a similar way. This was done to establish a functional set. So to the extent that Ss constructed answers in the abstract fashion they were considered flexible or non-rigid. If S followed the set pattern he was said to be rigid.

Results: (1) There seemed to be no evidence for a generalized rigidity trait.

(2) Submissiveness was more closely related to rigidity than any other trait.

(3) The authors felt that high rigidity was indicative of high ego-involvement.

(4) There seemed to be no evidence that high rigidity meant poor adjustment.

Educational Implications. This study suggests that it would be worthwhile to rate school children in terms of overt manifestation of submissiveness and rigidity to check the feasibility of diagnosing rigid tendencies through the extent submissiveness is shown. Sociograms and "pecking order" rating sheets may be useful data gathering devices for estimating submissiveness. Results could be related to rigidity in solving subject matter problems. By carrying test correlation studies into the realm of overt behavior, as suggested, we may profitably break the circularity of paper-and-pencil correlation practice.

Brown [1] points out that there is much research indicating that rigidity is not a general personality trait. It is a variable that seems highly sensitive to environmental conditions. Therefore, it would be more promising to study it by measuring its variation as a function of manipulated variables than by using factor analysis or straight test correlations. In education it would seem plausible to look for the effect of specific teacher behaviors on the amount and kind of rigidity.

Among a variety of special meanings of rigidity, Brown mentions two: (1) Rigidity as a defense mechanism that varies directly with S's anxiety, and (2) as a component of low intelligence due to a kind of neural inertia. In this study Brown examined the relation between the first type and authoritarianism.

He correlated scores of three tests: (1) The California F-Scale, an implicit measure of authoritarianism, (2) a test developed by McClelland "et al." designed to gage S's "need for achievement," and (3) a slight modification of Luchins' "Einstellung" test. Measures were taken under two conditions, authoritarian and permissive or relaxed.

Results: (1) Ss registered a greater "need for achievement" in authoritarian atmosphere.

(2) In the relaxed situation there was no significant relation between "Einstellung" and authoritarianism scores. But under the authoritarian atmosphere the correlation was .40, significantly greater than zero.

(3) In the ego-involved group (Ss working under the authoritarian atmosphere) those getting average scores in "need for achievement" were highest in "Einstellung."

(4) Ss showing high "need for achievement" got highest number of correct answers for the water jar problems. (Number of correct solutions and "Einstellung" are somewhat independent although the same instrument measured both. The reason is that Ss could have gotten all answers correct by using the complex formula.)

(5) Those having moderate scores in "need for achievement" reflected most defensive behavior in the go-involved situation. These Ss were said to be "security" minded.

Educational Implications. (1) Although the authoritarian teacher probably stimulates more drive to earn grades than the permissive teacher, the negative effect is reduced flexibility in problem solving.

(2) Ss having an authoritarian attitude profit most in terms of flexibility when working under a permissive atmosphere.

(3) "Security minded" Ss are in particular need of practicing problem solving under objective conditions, i.e., where their behavior has little chance of putting S in a defensive position. (See remarks concerning the studies of Marks in the next paper in this series.)

It should be mentioned that the above study by Brown is different from most other work reported in this paper because he used the tests in such a way that his results were in terms of relations between controlled conditions and test behavior. This method seems to be much more fruit-

ful for providing practical knowledge for the teacher than correlations that involve no data about environmental effects.

Moresko, Rubin, Shontz, and Morrow [9] correlated a measure of rigidity of attitudes about personal habits with scores on a test designed to gage anti-democratic ideology. Measures employed: (1) RAPH Scale: Intended to measure rigidity of attitudes about personal habits. S was asked to rate given statements on a six-point scale, ranging from complete agreement to complete disagreement. A preliminary scale of 32 items was boiled down to 20 items on the basis of an unspecified method of item analysis. Items were divided into two main groups: (a) Statements about opposition to change, and (b) items alleged to measure intolerance of ambiguity.

(2) The second test was the F-Scale constructed in the California Attitude Study. It is supposed to measure fascistic trends or attitudes about underdogs, nonconformists, overidentification with power, submissiveness toward "fate," and conformity to conventional values. It has been used by Rokeach and others.

Ss were 188 college students taking two beginning courses in psychology. Most of them were freshmen and sophomores.

The authors predicted that RAPH scores would show individual consistency as measured by an odd-even reliability coefficient and by an item discrimination index. Also, they predicted that the RAPH and F-Scale scores would correlate significantly in a positive direction.

Results: (1) Odd-even reliability of the RAPH Scale corrected by the Spearman-Brown formula was .78.

(2) Most of the RAPH items had promising discrimination values.

(3) Correlation between RAPH and F-Scale scores was .62, significant beyond the .01 level.

The results were interpreted to mean that there is rather high individual consistency of attitudes about personal habits among urban, middle-class American college students, i.e., they reveal rather stable patterns of rigidity. Also, this kind of rigidity is significantly related to antidemocratic attitudes. Rigidity was taken as a defense mechanism for reacting to threatening situations.

Educational Implications. Because of the tenuous assumptions about what the tests are supposed to measure and the limited sampling, it is difficult to go along with the above interpretations. However, these results plus common experience, suggest that schools need to work harder at demonstrating the utility of democratic living. Our first task is to make more thorough diagnosis to determine what functions in our society condition and nurture anti-democratic attitudes. Only after sufficient diagnosis can we construct school experiences for more effective democratic education.

Cattell [2] approaches the problem of rigidity through factor analysis. He has tried to isolate various kinds of rigidity. By using seven two-minute tests, which required by and large a shift in writing letters and sentences from the normal way to a reversed way, Cattell explored the possibility of factoring out what he called "disposition rigidity," which amounts to the disparity in time and accuracy between performing tasks normally and in some novel way. The greater the disparity the greater the disposition rigidity. This "g" factor is present in sensory, perceptual, and symbolic processes. In order to measure disposition rigidity Cattell suggests that: (1) well habituated responses be used. (2) Place little demand on intelligence. Compare the habituated behavior with the efficiency of performing the same task differently. (3) Maintain peak motivation. (4) Construct most items to elicit motor behavior while exploring other response patterns. (5) Make the tests about as long as I.Q. tests.

Educational Implications. In the opinion of the writer factor analysis does not represent an efficient method of either describing behavior or finding important

functional relations. Factor analysis seems to contain the assumption that through paper-and-pencil responses it is possible to construct a taxonomy of behaviors, which represent stable personality components. The well nigh overwhelming task that it poses is the establishment of an adequate sampling of paper-and-pencil responses indicative if not representative of all other kinds of behavior. Also, the selection of pure test items is a problem that promises little hope of establishing the kind of consensus demanded in a science. In spite of these criticisms, it seems that factor analysis is helping to draw attention to the need of making more rigorous definitions of response classes.

Weisberger, Jr. [16] constructed and partially standardized a questionnaire intended to gage conscious perseveration, which was defined as the persistence of sensations, words, emotions, and ideas to remain in the mind. The purpose of the study was to explore the possibilities of the questionnaire as a rough screening device in identifying maladjusted persons. Its utility in this respect was determined by correlating its scores with those of the Bernreuter Personality Inventory and the MMPI (Minnesota Multiphasic Personality Inventory).

Results: (1) Conscious perseveration as measured by the questionnaire was related with Bernreuter factors as follows: (a) .65 with neuroticism (b) .64 with introversion-extroversion (c) .60 with lack of self-confidence. (Error value of all these r's was .10.)

(2) Correlations with MMPI factors: (a) —.54 with K, which amounts to a kind of severity the person invokes upon himself. (b) .47 with Hs (hypochondriasis) (c) .70 with Pt (psychasthenia), and (d) .65 with Sc (schizophrenia) Error of all r's was .09.

(3) Provided a high enough cut-off score was used, the Perseveration Questionnaire was useful in identifying nearly all Ss rated as maladjusted by the MMPI.

Educational Implications. The obvious assumption in this study is that the Bernreuter Inventory and the MMPI are valid measuring instruments. But there is considerable controversy in this matter. Apparently, the Perseveration Questionnaire is easy to administer. Because it seems to have some promise, it deserves to be compared with an outside criterion of actual behavior patterns. What seems to be needed is an investigation of how such instruments are related to well defined response classes, determined empirically. (At Michigan State University Carpenter and others are making a concerted effort to define useful response categories for more objective descriptions of classrooms.)

Solomon [13] was interested in correlating Luchins' "Einstellung" measure with the ability to understand various aspects of the scientific method. His use of Luchins' test was similar to Rokeach's employment. S was said to manifest rigidity if he failed to shift to the simple mode of solution after having solved a number of items with the complex formula. He constructed a test of 33 items designed to test understanding of 18 aspects of the scientific method. Items concerned the ability to recognize logical hypotheses, valid experiments, and the like. Results indicated that college students who were least rigid displayed better understanding of the scientific method than rigid Ss. It was thought by the author that these results support the claim that rigidity is a general personality trait. A necessary assumption is that it requires intellectual flexibility to acquire a grasp of the scientific method.

Educational Implications. One general weakness that seems to plague most test correlation studies is that generalizations are "ad hoc" in the sense that other tests with equivalent titles often produce much different results. Therefore, the generality of conclusions is quite limited. But this study certainly raises the important question: Will other measures of intellectual rigidity show comparable correlations with an understanding of the scientific method?

Further study, of course, is needed. Also, is rigidity in problem solving related to actual success in applying the principles of science to specific problems? If scientific research is regarded as a class of problem solving behavior the logical answer would be yes. But we need more detailed information before a broad generalization can be accepted.

A second study in a series on mental rigidity by Solomon [14] involved testing the hypothesis that mental comprehensiveness is inversely related to rigidity. Comprehensiveness was defined as the ability to integrate related concepts. Ss were told to define a list of words representing biological phenomena.

After they had defined the terms they were told to indicate how the terms were related. It was possible to subsume all concepts within one broad conceptual scheme. Ss who did so were said to have the highest comprehensiveness measurable by this test. A rather wide spread of comprehensiveness was found, i.e., some Ss were able to relate only a very few items under a single meaning while others integrated all concepts into a single generalization.

Ss were divided into the rigid and non-rigid by using a variation of Luchins' "Einstellung" test.

Results: There were significantly more non-rigid Ss in the highest category of comprehensiveness. And there were more rigid Ss than non-rigid ones among those who ranked in the lowest class of comprehensiveness.

Educational Implications. Ability to integrate and synthesize ideas is often regarded as a major function in creativeness. It is not surprising to find comprehensiveness and rigidity inversely related. The important question for education is: What kind of experiences stimulate growth in comprehensiveness? This study points up the need for research designed to identify the experimental components in rigidity and comprehensiveness. This seems to call for more emphasis upon controlled experimentation rather than test correlations.

The third study by Solomon [15] was a continuation of the investigation of the relationship between comprehensiveness and rigidity. He used an actual classroom situation in which Ss were required to work on a series of simple experiments concerning the adjustment of plants to the environment. A pretest of three items was given about (a) how plants adjust, (b) whether or not they grow more at night than during the day and why, and (c) some explanation of plants turning toward the light. The same questions were administered after Ss had completed the series of experiments bearing on plant adjustment. Solomon speculated that Ss with high comprehensiveness and low rigidity would show the greatest gain on the post test. Although there were exceptions, results in the main bear out his speculation.

Educational Implications. The three experiments by Solomon are significant because they represent a kind of follow through from non-classroom measures to estimates of behavior in the normal classroom. This general strategy deserves much broader adoption in educational research. Too many studies stand as isolated bits with only scattered attempts to relate the bits to normal teaching operations. Although Ss who were rigid and displayed the least comprehensiveness gained less than Ss found at the opposite extreme, it is interesting to find that they made significant gains as a result of their experimental work. Experience in scientific problem solving seems to help nearly all Ss to attain a better grasp of useful information.

Goodstein [6] investigated the relationship between intellectual rigidity and social attitudes by correlating results of a modification of Luchins' original water jar test with certain other paper-and-pencil instruments designed to measure aspects of social attitudes. Tests correlated with the Luchins type "Einstellung" measure were: (1) Shipley-Hartford Retreat Scale: This

consists of multiple-choice vocabulary items and a fill-in abstractions test, which requires rapid shifting from one kind of problem to another. Abstraction score divided by the vocabulary score equals the Conceptualization Quotient (CQ). Hence, three scores from this measure were gotten: (a) abstraction score (b) vocabulary score, and (c) CQ.

(2) This was a test using anagrams of the Rees and Isreal type. Ss were given mimeographed sheets with a list of 50 anagrams. Each anagram had five letters. The 25 items were used for set conditioning. The second 25 were critical anagrams solvable by the set way plus other ways. If Ss perseverated in using the set mode for the second 25 anagrams they were said to show intellectual rigidity.

(3) Four of the Thurstone Attitude Scales were used: (a) Attitudes toward the Bible, (b) toward censorship (c) toward patriotism, and (d) toward law.

Ss ranged from 18 to 38 years of age. N was 150 and all college undergraduates. There were 120 males and 30 females.

Results: (1) Very low correlation between any two rigidity tests.

(2) No consistent relationship between rigidity and attitude tests. Average r was .02.

(3) CQ scores and age were significantly related. (Probably due to speed factor.)

(4) Measured attitudes seemed relatively independent. Evidence: low intercorrelations.

(5) There were no convincing grounds that rigidity was significantly related to stability of social attitudes.

Goodstein puts his finger on a possible source of error that probably pervades most test correlation studies. He says that the probable variance in mental set among Ss toward the tests may have helped account for the null results. The same reasoning suggests that *positive* results obtained by other researchers may be partly due to the conditioning of temporary impressions, which would tend to make the results an artifact of the conditions rather than reliable measures of personality traits.

Educational Implications. We need to be very careful in noting the effect of test conditions on paper-and-pencil type behavior. It is probably more fruitful to determine the effect of controlled variables on test scores than to seek for personality factors. The reason is that humans are tremendously variable in behaving and much of the variation is due to changes in surrounding conditions. Even if personality traits could be isolated they would still have to be related to environmental changes. A person tested as very high in submissiveness may be aggressive in a number of real life situations.

CRITIQUE OF THE PERSONALITY APPROACH STUDIES

1. The question "Is mental rigidity a general trait" leaves much to be desired in the way of providing a proposition capable of being answered unambiguously. Any single answer depends upon the particular test items. There seems to be little likelihood of reaching an agreement as to what items measure rigidity. The difficulty is comparable to measuring the speed of a train with an assortment of timers running at different rates and where there is no basis for expressing the reading of one clock in terms of another, and where there is no consensus on which timer should be used. The question has been answered both ways without establishing which of the two answers is more tenable.

2. Virtually all tests of rigidity have no established validity. It is not enough to operate only on assumed validity. The tests need to be compared with actual performance other than the paper-and-pencil kind.

3. Teachers want to find efficient ways of modifying student behavior. But test correlations, as normally handled, give us scant knowledge on how learning develops.

4. It is likely that the reported reliabilities of tests are spuriously high. Learning involves behavioral changes, which occur almost continually. Therefore, to the extent response patterns change, test reliability is attenuated as a function of time between test and retest. This even dilutes the significance of split half correlations.

5. Correlation coefficients between standardized tests yield little information about the dynamics of behavior.

6. Test titles are often misleading because validity is usually assumed rather than demonstrated. Just what a test measures is more often than not a matter of private speculation subject to the likes and dislikes of the testor.

7. Tests are often scored in terms of dichotomous response classes, i.e., S either "passes" or "fails" an item. Even complicated weighting procedures supply only doubtful improvement. The claim that scales represent continua, behavior-wise, is partly based on pure speculation.

8. An objective test score does not throw light on how the respondent reasoned to arrive at his answers. A test pitched at one intellectual level may suggest that a person operating at a higher level is incompetent.

9. We are in great need of more adequate theories to account for learning. Correlation studies have contributed very little to the growth of useful theories. The reason is largely attributed to the kind of data furnished by test scores, which are not expressions of relations between behavior and independent variables. Environmental factors are important referents in theoretical statements.

10. Correlation studies do more to produce hypotheses than yield grounds for "proving" or supporting generalizations.

11. The most useful function of tests lies in their predicting power. But prediction is largely confined to group behavior and does not apply with much precision to the individual.

Along side these limitations the advantage of group prediction appears relatively small. However, we should not forget the diagnostic use of tests.

In light of the many limitations involved in correlation studies, a more plausible use of tests seems to lie in experimentation where *changes* in test behavior are studied as a function of changed conditions. This allows us to express results in terms of what conditions are imposed on S and therefore helps us determine improved ways of teaching.

Although the personality approach has given us some provocative statements and interesting implications for teaching and learning, it has been less productive than research conducted from the learning standpoint. The next paper will deal with the promising possibilities resulting from studies on mental rigidity investigated by researchers adopting the learning approach.

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EDUCATIONAL SIGNIFICANCE OF STUDIES ON THE RELATION BETWEEN RIGIDITY AND PROBLEM SOLVING

III. THE LEARNING APPROACH

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THIS is the third article in a series on mental rigidity. The purpose of the series is to draw out the educational implications from a number of studies and to compare the fruitfulness of two general methods of research. The two methods have been called: (1) personality approach and (2) learning approach, both of which were described in the first article. Studies in mental rigidity undertaken from the personality approach were discussed in the second article. The present report deals with the educational implications from research conducted from the learning framework.

As noted before the most common research method here is controlled experimentation. Paper and pencil tests are sometimes used, but under conditions where particular variables are controlled. Data are not often expressed in terms of correlations but as response frequencies, intensities, and latencies.

Luchins [9] did a series of experiments reported in a monograph on the effect of a number of controlled variables on "Einstellung" behavior. "Einstellung" is defined as the blinding effect presumably due to strong habits which stand in the way of elicitation of more successful modes of response. Luchins' paper is long and somewhat involved at certain points. There is room here for only the essentials of his basic experiment.

He presented his subjects with the now famous set of water and jar problems which required the subject to determine by reasoning a set of manipulations involving three water jars and resulting in a particular volume of water. A sample problem was solved by the experiments for S by a formula which was regarded as rather complex. The same formula was applicable for solving the first six problems, which were called "set" problems. Items "7" and "8" could be solved two ways, either by the set formula or by a much simpler method. The experimental variable was a verbal warning that S should remain alert especially after problem six. The purpose of this operation was to measure the effect of the warning on the tendency to overcome the set for using the original formula. Ss who continued to use the set method for problems "7" and "8" were said to exhibit "Einstellung" behavior. The central question was: How much change in the "Einstellung" effect could be attributed to the experimental variable? The ninth problem could

not be solved by the complex method but only by the simpler one. Luchins also wanted to determine the effect of problem "9" on problems "10" and "11," which could be solved either way.

Results showed rather convincingly that the verbal warning reduced "Einstellung" significantly. Also, the experience of being confronted with a problem not solvable by the established method decreased "Einstellung" in solving subsequent problems. These results were fairly stable for students ranging from intermediate grades through college graduates. Other findings include:

(1) Recovery from "Einstellung" seemed to be greater in adults than in public school children.

(2) "Einstellung" was not linearly related to I.Q. Persons having very high and low I.Q.s showed more "Einstellung" than the middle group, but probably for different reasons.

(3) The amount of "Einstellung" seemed to be partly a function of S's attitude toward the problem. If he felt the task was trivial he did not seem to care whether he used the complex or simple solution.

(4) Ss with pronounced docility seemed to exhibit more "Einstellung" behavior than less docile Ss.

(5) Ss who regarded the tasks as tests of speed showed greater set strength.

(6) Increased emotional tension seemed to go with increased "Einstellung."

The fact that Luchins was so careful to criticize his own methods and ideas as the work progressed helped produce a study of outstanding merit. Where he seemed to falter was in evaluating the adequacy of various explanatory hypotheses to account for "Einstellung." For example, Luchins eliminated the recency principle as inadequate somewhat too summarily. The very phenomenon "Einstellung" suggests that S tends to behave as he did the *last* time in the same or similar situation. Without some noticeable change in the stimulus complex "Einstellung" remained relatively unchanged. The directions "Don't be blind" certainly modified the stimulus effects of test problems "7" and "8." Inclusion of the warning *altered* the cue pattern. Such alteration was followed by a noticeable decrease in set behavior. The principle of recency surely cannot be said to be incompatible with these results. (Although recency emphasizes the response side, stimulus changes cannot be ignored. Contiguity works better here than recency alone.)

Instead of the recency principle, Luchins preferred to explain the data with the idea that the person used intelligent assumptions, which somehow entangle S in a web of overgeneralization. But his explanation is not clear because he does not elucidate the difference between mechanical and reasonable behavior. Since these terms are vague it is difficult to judge the adequacy of his explanation. Even if reason and mechanical behavior are made mutually exclusive by definition, it is always possible that they may *occur* simultaneously. For example, a logical reason may be given by S for his reaction. On such grounds we may say that he acted with reason. But his overt behavior (excluding verbalizations) may very well fit the criterion of mechanical. We could argue that the verbalizations are so much rationalization that fail to change the nature of the overt set. The upshot of this is that Luchins' question "Is problem solving mechanized?" has no testable meaning. This gets into the problem of free will, which has so far defied a scientific answer. Assertions in this area are expressions of faith rather than testable hypotheses. But the many issues he raises make his work highly valuable.

Educational Implications. (1) The study throws added doubt on the efficiency of pure drill, which may establish with too much strength the tendency to perseverate. This criticism of drill suggests that we try harder to teach the child to expect the unexpected.

(2) It was demonstrated that Ss all the way from intermediate grades through

college could be easily conditioned to feel afraid, anxious, and tense and that these reactions were followed by heightened "Einstellung" in problem solving. This suggests that certain kinds of fear may be learned in school and that a consequence is a diminution of flexibility. A more thorough study of conditions and practices in schools that give rise to unnecessary anxieties and fears may lead to more efficient transfer.

(3) The finding that a mental set for speed in problem solving was followed by high perseveration suggests that the whole tempo of teaching should be studied in relation to rigid tendencies.

(4) There was some evidence to show that a number of Ss were learning little else than being good followers. Such Ss may be prone too much toward giving what the teacher wants with too little concern for independent thinking.

(5) Although the evidence is far from conclusive, students from the more progressive schools seemed to be less rigid. They also recovered more quickly from habituation. These exploratory statements need further examination.

(6) What the teacher says and does and consequent development of attitudes and expectancies appear to have considerable influence on adjustment in school. Here we need to isolate strategic operations.

(7) How do the autocratic and democratic learning situations differ in the amount and kind of rigid behavior they evoke? Although some work has been done here, much more is needed.

Luchins and Luchins [11] studied the effect of effort on "Einstellung" behavior in a maze-tracing situation. Eleven three-path pencil-and-paper mazes were presented individually to two groups of Ss. One path in each maze ended in a blind alley; another path was a very circuitous one which led to the goal in all mazes except maze No. 9; and a third path was quite short and direct. The indirect or circuitous path was the only operative one in the first group of mazes, which were used to establish a set for the indirect path. Mazes 7, 8, 10 and 11 could be solved by following either the long or most direct alley. Maze No. 9 could be solved only by using the direct route.

Effort was varied by using a mirror, which was arranged so that S had to look at the mirror image to guide his way through. Group I worked all mazes by first using the mirror and repeated the operation without the mirror. Group II worked in reverse order, i.e., they first traced without the mirror, then with it. It was found that the mirror noticeably increased the effort required to follow the circuitous route but not the direct path. Ss were told that the test was used as an overall I.Q. measure and cautioned Ss to do the best they could. They were also advised that errors would be counted in terms of the number of wrong alleys followed and number of times pencil marks crossed path boundaries. In addition they were told to work as quickly as possible.

Results: (1) Use of the mirror increased effort as evidenced by fidgeting, straining, sweating and verbal remarks.

(2) Group I Ss during initial presentation, in which mirror was used, displayed more perservation than Group II Ss working the mazes first without the mirror.

(3) In the first presentation, Group I failed problem No. 9 (not solvable by the set method) 55 per cent of the time and Group II failed only 18 per cent of the time.

(4) Both groups had very low perseveration in the second presentation.

(5) Early in the set-inducing series some Ss immediately looked for the long route and started tracing without first inspecting where it led.

(6) During the first presentation, Group II shifted more readily than Group I.

(7) Principle of least practice, often used to account for certain kinds of learning, was not satisfactory in accounting for these data.

(8) Hull's concept of reactive inhibition says that responses build up a negative

drive in direct proportion to the amount of effort involved. Therefore, responses requiring more effort should extinguish more quickly than responses requiring less effort. But the reverse of Hull's prediction occurred. Responses that required most effort were the hardest to extinguish.

(9) According to Luchins, insight, expectancy, cognitive maps, and other field concepts were useful in accounting for the results.

Educational Implications. (1) It is probably axiomatic to introduce difficult tasks only when conditions allow plenty of time to develop understanding. Teachers sometime violate this especially when they find they are behind schedule in covering subject matter. A slave-like submission to prescribed curriculum schedules may nurture a host of practices that stifle flexibility.

(2) The permissive atmosphere probably allows more flexibility in problem solving than the authoritarian atmosphere.

(3) Forcing students to put forth great effort by inducing anxiety may condition undue rigidity.

Marks [14] did a controlled experiment to describe how problem solving differed in two situations: (a) "Real life" situation, and (b) a textbook situation. The "real life" situation consisted of direct interaction with the problem, while the textbook condition was a story about a fictional character confronted with the same problem. The student was to "advise" the character how to solve the problem. Underlying rationale was that in the "real life" situation the person finds himself within the problem context, making it almost impossible to see himself objectively. Therefore, the person is more likely to show defensive reaction in the "real life" situation than when he is less involved personally. Hence, flexibility would be greater in the latter. Results seemed to support the rationale.

He also found that a lecture on problem solving to a college group had no discernible effect. The textbook situation evoked more pertinent vocalizations about the problem, and the number of these vocalizations during problem solving is evidence of necessary awareness of the nature of the problem. What he means by vocalization is not mere glibness but statements about pertinent elements in the problem.

Educational Implications. (1) This experiment is novel since it suggests that textbook training seems to stimulate more flexibility than training designated as "real life" situations. The explanation offered was that the individual is more vulnerable to threats which evoke more defensive reactions in the "real life" situation than in the textbook situation. Assuming that it is desirable for children to develop with the minimum of rigidity, they could probably benefit from experience in evaluating textbook situations for learning objective and flexible reasoning habits.

(2) Some pro and con polemics have been waged over the desirability of reading fairy tales. Although the goodness of such experience would be both a function of how the fairy tales are written and what they contain, in terms of stimulating flexible and imaginative behavior free from induction of defensive reactions, fairy tales may prove useful. Perhaps it is more important how fairy tales are used rather than whether they are read or not read. If they are used to stimulate critical evaluation of behaviors depicted, flexibility may be improved.

(3) The method of Socratic questioning may be particularly valuable for flexibility because it gives S the opportunity to become more aware of his own assumptions and helps him see where his understanding is vague or inadequate.

(4) To prevent rigidity due to ego-involvement, students may profit from considerable experience in solving textbook problems before applying learned material in real life situations. This does not mean that textbook problems need to be artificial and uninteresting; but it means that Ss will probably grow in flexibility if placed

in the role of critical judges where ego-involvement is minimized. The important point is that such textbook training may need to occur in ample amount *before* real life problems where objective analysis is more difficult.

Another experiment along the same line was performed by Marks and Ramond [13]. S was faced with a concept formation task. He was told to sort 26 stimulus cards having inscribed figures which varied in shape, size, color, and position. S sorted the cards into four exclusive groups. These conditions composed the "real life" situation. The textbook mode was less personal in that S read a story about a person faced with the same problem. S was asked to help the story-book person solve the problem. There were 76 college students in each group.

Results: (1) There were 32 correct solutions in the textbook group while only 16 solved the problem under the "real life" situation.

(2) The textbook group made significantly more vocalizations about the problem, i.e., they were heard to identify more strategic elements in the problem.

(3) In both groups, successful solvers made more vocalizations than non-solvers.

(4) A tetrachoric correlation between the number of correct solutions and vocalizations was .85

The same educational implications are applicable to these results as indicated in the preceding study.

Werner [20] speaks of different kinds of rigidity. (1) Simple perseveration or a single unnecessary repetition of an immediately preceding response. (2) Repetitive perseveration or multiple occurrence of previously performed patterns. (3) Delayed perseveration or a recurrence of a pattern not immediately preceding the current response. Werner felt that brain injured mental defectives were more prone to show delayed and repetitive perseveration than equally intelligent endogenous defectives. To test his supposition he matched two groups of defective children on I.Q. Ss in one group were defective due to brain injury (BI group) and the other group was composed of endogenous defectives (E group). His tests included reproduction of rhythmic tones, apprehension of pictures, reproduction of dot patterns and reproduction of words.

Rhythmic Tone Test. The experimenter produced rhythmic tone patterns by pressing a key wired to an oscillator. Short and long beats were presented in various combinations not exceeding five beats per item. S was asked to repeat each pattern immediately after hearing it by operating a similar key wired to the oscillator. Ss were blindfolded during the test.

Results: (1) BI group exceeded E group on all types of rigidity, with the difference between groups in repetitive and delayed perseveration significant at .01 level. (2) Total number of wrong patterns: (a) BI group 293 (b) E group 221.

Apprehension of Pictures. Simple drawing of familiar objects were presented singly on cards, each one exposed for one-fifth of a second. There were six sets with five cards in each set. S was told to name the object as soon as he saw it. A short rest period separated the series. This whole process was repeated the next day so that a total of 60 trials was given.

Results: BI group exhibited more repetitive and delayed rigidity than the E group while no significant difference was found between groups in simple perseveration.

Dot Configurations. Patterns of dots were presented to S for one-tenth of a second per pattern. S was asked to reproduce the pattern immediately after exposure. Two series were presented. One was called the similarity series in which patterns of dots had similar shapes. The other set was composed of dissimilar dot patterns. BI and E groups were compared in the amount of rigidity in both series.

Results: BI group exhibited more perseveration responses especially within the non-similarity series. This was interpreted

to mean that much of the rigidity found in brain injured children is due to abnormal dissociation.

Reproduction of Words. Ss were given a group of words orally and told to repeat them immediately. Some groups had 4 words; other groups contained 6 words. The 4-word groups contained closely related words while the 6-word groups were less homogenous in terms of logical association.

Results: E group tended to learn the 4-word lists as a whole. Consequently, they showed less tendency to confuse the words in the two series than the BI group. Interference of words between series was taken as rigidity.

Educational Implications. (1) Well constructed rigidity tests may prove to be useful instruments for identifying children who will have considerable trouble with novel problems. Although other studies seem to indicate that I.Q. and rigidity are not highly related, such studies dealt with college Ss. Therefore, rigidity tests may prove useful in diagnosing Ss on the lower end of the continum (I.Q.).

(2) Rigidity tests may also be useful in detecting behavioral irregularities such as abnormal dissociation and disintegration.

In a study of the learning and retention of concepts Underwood [17], compared the effects of massed and distributed practice. Stimuli varied in form, size, and shade, each dimension having three values. There was a total of 27 stimuli presented by memory drum type apparatus. Size and shade were "large and light," "medium size and dark," and the like to a total of 9 different concepts.

Results: (1) Learning was faster under distributed practice. (2) Concepts based on medium sized figures were harder to learn than concepts based on either the largest or smallest size. This was probably interference due to stimulus generalization. (3) Principles normally used to account for rote learning also seem applicable in accounting for concept formation, a higher order mental function. (4) The experimental variable seemed to have no effect on retention. Although this study was not designed to investigate rigidity, it is relevant to the extent that errors in concept learning attributed to stimulus generalization suggest a kind of perseveration similar to rigidity.

Educational Implications. (1) The interesting finding in this experiment was that the same learning concepts used to explain rote learning are also useful to account, in part, for concept formation. Specifically, the idea of generalization seems to help account for both kinds of learning. These findings suggest that principles of simple learnings should be exploited more to help account for higher order mental processes, such as problem solving and critical thinking.

(2) If the phenomenon of generalization is operative in learning concepts, then it would seem economical to present a number of different situations in which a newly learned concept is applicable. Taking advantage of generalization during learning means giving attention to application soon after factual acquisition. Principles widely applied are more likely to be used than concepts limited to rote learning.

Kendler [7] studied the strength of set as a function of massed and distributed practice using Luchin's water jar problems. He tried to determine whether massed practice resulted in greater set strength in solving Luchins' problems than distributed practice. He used 100 undergraduate male students in the College of Arts and Science at New York University. One group solved eight set problems by the "complicated" formula, i.e., S had to fill the largest container and make three pourings into the other two containers before the correct amount was reached. The criterion problem could be solved either by the set formula or a simpler way involving only two jars. Failure to use the simpler solution was taken as evidence of rigidity.

Results: (1) Massed practice was followed by a stronger mental set.

(2) Non-rigid Ss took longer to solve the set problems.

(3) It was reasoned that mass practice weakened non-set tendencies sooner than working under distributed practice; therefore, if the tendency existed to use the simpler solution in the set problems such tendency was weakened more quickly under massed practice than under distributed practice.

Educational Implications. (1) Rigidity seems to imply that S does not pause to ask critical questions about his procedures but continues to perform somewhat on a mechanical basis.

(2) The best treatment for rigidity is prevention. If we want to prevent it we must point out the necessity for shifting and to help provide students with a mental set by which he learns to expect unusual events.

(3) In problem solving tasks that require frequent shifting, Ss will probably be more efficient if tasks are punctuated with a number of short rest intervals. Ss taking tests that require considerable critical thinking will probably do best if not placed under a time limit. Therefore critical thinking tests need to be made short enough so that most Ss have plenty of time to finish the examination. However, tests that call only for recognition of factual information may be set up as speed tests without apparent ill effect because simple memory probably requires little critical thinking.

Sheffield [18] did a well controlled experiment on extinction. The purpose was to determine whether distributed practice influences the effect of partial reinforcement on resistance to extinction.

Ninety-two rats were divided into two groups of 46 each. Group I was trained for 30 trials and given 100 per cent reinforcement. Group II was given the same number of trials and reinforced randomly on 50 per cent of the trials. Half of each group was trained under massed practice (15 second interval between trials) and half under spaced trials (15 minute interval). Rats were put in an "I"-shaped box and required to run the entire length of the box to reach the goal.

Results: (1) Ss given 50 per cent reinforcement and massed practice had stronger resistance to extinction than Ss receiving 100 per cent reinforcement and massed practice.

(2) Under spaced training there was no difference in resistance to extinction between Ss having 100 per cent and 50 per cent reinforcement.

Educational Implications. It is obviously a long leap from rat behavior to college student behavior. Nevertheless, in light of human experiments and everyday observation, the above study seems to suggest the following statements:

(1) Frequent reinforcement is more effective at the beginning of a learning experience than during later stages. Education-wise it seems reasonable to make sure that Ss perform correct responses during the early stages of learning and to be liberal with verbal approval when correct responses are made.

(2) To fortify the student against forgetting, everything he does should not be rewarded. As skill is improved, reinforcement should be less frequent, and should probably be confined to obvious improvement.

Wilcoxon [21] reported the effects of abnormal fixation on learning in two related experiments. His first study was designed to determine the effect of partial reinforcement (rewarding S for only a part of the time he makes a correct learning response) and non-differential reinforcement (rewarding wrong responses as well as correct ones). Rats were forced to jump in a Lashley type apparatus by application of an air blast. They were made to jump across a gap to either of two windows, which could be locked when desired, forcing the rat to fall into a net several feet below. Hence, there were two foci of punishment, where the rat bumped his nose on a window and the fall.

There was a training and testing series.

During the training series 15 rats received continuous reinforcement (reward for every correct response); 13 rats received partial reinforcement; and 12 rats were placed in an insoluble situation. Results of training are as follows:

(1) Ss under continuous reinforcement required 7.4 trials to adopt a consistent response. S.D. 8.06.

(2) Ss under partial reinforcement required 25.3 trials to adopt a consistent response. S.D. 21.44.

(3) Ss in the insoluble situation required almost 60 trials to adopt a consistent response. The S.D. here was 47.2. It is interesting that although this group showed greater variability they finally adopted a consistent response even when failure was inevitable.

The purpose of the testing series was to determine to what extent responses learned in the training series were fixated. Results showed that:

(1) 35 per cent trained under continuous reinforcement were fixated.

(2) 92 per cent trained under partial reinforcement were fixated.

(3) 58 per cent experiencing the insoluble problem were fixated.

The very high percentage in (2), above, was said to be due to the alternation of reward and punishment during training. Since the markings in windows were interchanged from trial to trial, it was difficult for the rat to learn the correct association and because both windows were locked on some trials.

Experiment No. 2. The purpose of this experiment was to show the effect of different techniques toward helping Ss unlearn habits of fixation. The 24 rats that developed position fixation in the first experiment were used.

Condition A. Ss were forced to jump when the window to which they were fixated was locked while the other was left unlocked. If S jumped to the nonpreferred (open) window before completion of 100 trials, he was given 30 additional practice trials. He was then tested by re-introducing the cards in a regular discrimination sequence.

Condition B. The card containing the negative marking (previously used to mark the closed window) was retained for the same purpose. No card was placed in the open window. The negative card alternated from side to side in a regular discrimination order. If S jumped to the nonfixated window within 100 trials he was given 30 more practice trials, after which the positive card was used again, with no change in the alternation procedure.

Result: 82 per cent were able to unlearn their fixation when the stimulus complex was changed. Differential reward was more effective when conditions were changed.

Educational Implications. (1) Rigid habit patterns acquired as a result of indiscriminant use of reward and punishment are unlearned more efficiently when the environment is changed than under the original conditions. When the personalities of teacher and pupil clash it is advisable to minimize their interaction.

(2) If the child is subjected to problems that he is unable to solve he will show considerable variability of response, but will finally fixate by adopting a set pattern although the pattern leads to no objective solution of the problem. The implication here has been long recognized, viz., that learning must begin at the level where the child is able to succeed.

(3) Indiscriminate use of reinforcement is inefficient for growth in problem solving. The practice of approving every act of the child does not make for efficient reasoning. Reinforcement seems to be a significant operation that affects almost all kinds of learning; but it can easily be misapplied to dissipate growth in problem solving.

(4) Differential reinforcement in problem solving is probably best applied to improvement. And if flexibility is desired teachers should be careful to approve manifestations of plausible response variations.

(5) The kind of practice that seems to be needed in problem solving is the exercise

of imagination, i.e., helping students get experience in producing a variety of possible answers to a problem instead of drill in memorizing one particular answer. It is perhaps more important to stimulate and sustain variability of response than to emphasize correctness *during early schooling.* In other words, it is probably easier to prevent undue fixation than to unlearn it. Perhaps much could be found in school practices to indicate that Ss are learning unfruitful fixations, and that growth in imaginative responses is given more lip service than practical augmentation.

(6) S–R learning principles involving reinforcement as an explanatory concept seems to be useful in accounting for fixation.

Luchins [10] examined the relationship between rigidity and concreteness of thinking. His criterion for rigidity was failure to work four critical water jar problems, solvable only by a simple formula after having been conditioned to work similar problems with a more complex formula. The problems were set up as follows:

Problem No. 1. An illustration item solved by the experimenter with the complex formula.

Problems Nos. 7–10. Could be solved by either method.

Problems Nos. 11–14. Extinction items, solvable by only the simple formula.

Hence, failure to solve problems 11 through 14 was regarded as evidence of the highest rigidity that could be measured by the test. Concreteness of thinking was estimated by a subtest in the Wechsler Bellevue Intelligence Scale. Twelve pairs of words were presented such as "orange-banana," "coat-dress," and the like. Scores were based on three levels of abstraction. An abstract answer was scored 2; a concrete-functional answer was scored 1; and failure was 0.

Results: (1) 25 Ss solved all critical water jar problems correctly. This group was considered least rigid.

(2) 22 Ss failed to solve the four critical items. This was the rigid group.

(3) Two other groups ranged between the above groups in terms of the use of the direct method on problems 7–10.

(4) Least rigid Ss showed smaller percentage of concrete-functional responses to word pairs than rigid Ss.

(5) Least rigid Ss made more abstract responses than rigid Ss.

(6) Least rigid Ss made fewer failures on word test.

(7) *If failure to solve items 7–10 (solvable by either method) was taken as a criterion for rigidity there was no significant difference between groups.* This finding is quite significant because Rokeach, Solomon, and others have used this criterion in a number of studies. The fault with it is that since S has been set to use the complex solution and it *still works* for the critical items, the situation does not *demand* a shift in response. Therefore, his (Rokeach's) criterion not only failed to jibe with his definition of rigidity but it seems to be much less powerful than the one used by Luchins' in this study.

Educational Implications. (1) The more practical criterion of rigidity should be set up by making the critical items unsolvable by the set method. Either latency or failure should be used as a measure of rigidity. This may be applied to story problems in mathematics.

(2) Ss may need practice in translating concrete data into abstract forms as a possible aid for transfer.

Maier's [12] widely discussed work on productive thinking contains some interesting implications. The work boils down to demonstrating the effect of instructing Ss to be conscious of the danger of rigidity in problem solving. Maier says that an important process in reasoning is to inhibit habitual responses.

Educational Implications. (1) The teacher may effectively combat mental rigidity by repeating many times the disadvantages of rigid behavior.

(2) If an important process in reasoning is to inhibit habitual responses, then the teacher should be prepared to learn

what intellectual responses prevail in a particular problem solving situation and to diagnose problem solving behavior in terms of unfruitful perseveration. In mathematics, e.g., this calls for detailed analyses of what appears to be repetitive mechanical behavior when reasoning is required. Before habitual responses can be inhibited, it is necessary to know what habitual responses block flexibility.

(3) We need to pay more attention to the diagnosis of reasoning behavior by finding clusters of rigid responses. This seems to call for more widespread use of existing diagnostic instruments and perhaps the construction of new ones for particular subject matter areas.

(4) If further experimentation bears out the findings here that women tend to be more rigid in problem solving than men, we need to find what factors peculiar to the female sex give rise to rigid tendencies. Other studies suggest that submissiveness and anxiety are positively related to rigidity. Controlled experiments investigating the operations in classroom learning that contribute to submissiveness and anxiety need further study.

Buss [4] designed a controlled experiment in which the problem for S was to judge which of two classes a stimulus object belonged. Stimuli were small wooden blocks of various colors, shapes, heights, and sizes. They were presented one at a time in a display apparatus. A response was made by lifting the hand from one of two telegraph keys. Eighty college Ss were divided randomly into four groups of 20 each. Groups experienced a difference in the number of possible reinforcements during the training series by the experimenter controlling either the number of blocks or the proportion of possible reinforcements to a given class of responses. Two groups saw instances of a single class; the other two groups saw instances of both classes but differed in the number of cases for one of the classes. The latter two groups were reinforced differently; one group for all correct choices, and the other group for only correct choices of one class. During the training series a "vec" response (releasing the key marked "vec") was reinforced when tall blocks were selected. In the testing series the two responses had to be interchanged. Failure to shift was taken as rigidity. Results showed that during the first half of the testing series there was no difference between any two groups. But in the second half of that series those who learned where only members of one class of stimuli were presented had the most difficulty in shifting. These results are somewhat unique, but they are consistent with the learning idea that discriminations learned under differential reinforcement are weaker than under continuous reinforcement.

Educational Implications. (1) For increased flexibility tasks should be so constructed during initial learning that shifting is required. This is opposed to the practice of encouraging mastery of a single operation before going to another task. For example, it may be more worthwhile to introduce addition and multiplication together instead of sequentially. Reinforcement should be associated with manifestation of correct shifting.

(2) The study furnishes encouragement for using the more simple S–R concepts such as reinforcement, generalization, and discrimination in the analysis of conceptual learning.

(3) Students will have a more flexible use of verbal concepts when they are required to make a large number of discriminations to establish the meanings.

(4) A student will make more intelligent use of a concept when only partially reinforced during learning than if continuously reinforced. ("More intelligent use" means that he will be less likely to use the concept inappropriately in a problem solving situation.)

Schroder [17] examined the effect of different learning conditions on the amount and speed of shifting in a card sorting test. Sixty-six cards 3½ inches square each contained a design with both an inside and

outside form. Cards also varied in color. Two groups were trained to sort the cards on the basis of outside form only. Two other groups were trained to group them on the basis of color and inside form. All groups were tested with a series of cards in which the basis for grouping changed gradually from outside form to inside form. It was predicted that Ss trained to sort only on outside form would shift at a later point in the testing series and would consequently tend to take more time per item as the criterion test progressed. Results supported his prediction.

Educational Implications. (1) So long as the task does not change, rigidity makes for speed. Thus, a homogeneous, multiple-choice memory (non-thinking) test is more suitable as a speed test than one requiring problem solving.

(2) To increase flexibility in problem solving the teacher should probably encourage the expectancy that similar problems may require different methods of solution. Ss should be given practice in solving problems with similarities but which require different principles for solution.

(3) The instructor should give Ss experience in attending to a variety of cues. This means experience in sizing up the requirements of problems and practice in differentiating similar-looking tasks.

(4) Teachers should not evaluate Ss negatively because of slowness in problem solving. Flexibility requires time. Ss who see and test a variety of plausible hypotheses are being flexible, which should be positively reinforced.

Blanton [3] tried to determine the relationship between set shifting as measured by the Rorschach and other indices of rigidity when Ss were operating under "ego-threat." The condition designed to to establish ego threat was a disturbing interpretation of Rorschach performance.

Eighty college Ss were given the group Rorschach. Scores were "doctored" in such a way that serious maladjustment was indicated. They were informed of the significance of these low scores, which were said to threaten the ego. Then they were asked to perform tasks measuring perceptual speed, perceptual speed shifting, meaning set, and position set.

Results: (1) Ego threat seemed to affect only speed of shifting, which was significantly lowered.

(2) Rigidity was said to be related to:

(a) Persistence in solution of problems with ambiguous meanings (positively).

(b) Ability to overcome a set (negatively).

(3) Individual differences in habitual reactions to ego threats was taken as more important than the effect of anxiety on shifting.

Educational Implications. (1) The ideal concept of education is probably not appropriately expressed in terms of teaching methods but in terms of thorough diagnosis, which determines the kind of teacher-pupil interactions. There are perhaps as many ways to teach effectively as there are students.

(2) Classes need to be small enough so that the teacher can treat the pupil in accordance with the unique demands of his personality.

But the above implications have little likelihood of broad application. We shall probably continue to modify teaching practices in terms of statistical results.

Duncker [6] pointed out that the stimulus function of an object or even perhaps a concept is learned in two ways:

(1) By perception. The child sees the limb as part of the tree and fails to perceive or imagine the limb serving another function.

(2) By functional conditioning. For example, a stick that has just been used as a ruler will less likely be used differently. Duncker calls this *heterogeneous* functional fixedness because the object has been experienced as having a function different from that demanded by the situation to solve a problem. The flexibility

required to see a new function Duncker called *recentering* of the object.

His experimental problem was to determine the effect of pre-utilization of an object on recentering. Put another way: If you have learned to use a tool a certain way, what effect does this have on the probability of using it in an entirely different way?

EXPERIMENT

I. Several problems were used. For each problem there were two settings. One setting involved previous experience by the Ss of some critical object in the problem. The second setting did not involve this pre-utilization.

A. *The Gimlet Problem.* S was to hang three cords from a board using only the cords, 2 screws, and the gimlet. In the pre-utilization setting, S was told to drill the holes with the gimlet. Thus, S used the gimlet in a certain way. In the other setting, the holes were already drilled. The solution was to use the gimlet as the third screw and hang the cord on it. Clearly, then, in one setting there were two functions for the gimlet (FI and F2). The problem was to determine whether FI interfered with F2. The answer was yes.

B. *The Box Problem.* Three candles were to be placed on a door at eye level. Materials were tacks and three small pasteboard boxes. In the pre-utilization setting, the materials were not in the boxes. Hence, FI and F2 were clearly present in the pre-utilization setting. Results were comparable to those in "A."

Generalization. Adoption of the solution function of the critical object was about half as frequent after pre-utilization experience than under non-pre-utilization.

Speculations. Duncker felt that the less relevant the FI function was to the solution of the problem the less interference with F2. But results did not back up the guess. Results forced Duncker to say that interference depended upon the appropriateness of the first stimulus function—the more appropriate, the more interference. For example, boxes holding the candles (central objects) were more appropriate than central boxes holding irrelevant material.

Educational Implications. (1) For more flexible use of mechanical tools, it is probably advantageous to get Ss to think in terms of the *general function* of any particular tool rather than just an association between the tool and a specific use. The idea of general function implies an understanding of the tool in terms of its mechanical principles.

(For other implications see the next study by Adamson.)

Adamson [1] investigated "functional fixation" in using tools in a set of novel problem situations. Functional fixation was taken to mean the manifest failure to use a tool in novel ways after having used it immediately before in a different and more orthodox way. Experiments amounted to a repetition of Duncker's work on fixation where Ss were asked to arrange small objects when there was insufficient supply of normal fastening devices such as thumbtacks and wood screws.

Results: Difference in time to solve all three problems favored the control group, i.e., Ss in that group required less time than Ss in the experimental groups. Therefore, it was concluded that functional fixedness was found to be positively related to pre-utilization of critical tool objects.

Educational Implications. (1) To prevent rigidity in the use of tools, it is probably best to interpret the function of the tool in terms of its working principle(s) and to have Ss practice in analyzing problems by looking for principles of solution. By understanding what the problem requires and thinking in terms of principles instead of specific stimulus functions, it may increase flexibility in the use of tools. The idea is that principles are more-readily transferred than a specific function associated with a tool. For example, instead of having Ss learn that a screw driver is a tool for tightening or loosening screws, it could be learned as a tool that could

implement both the principle of leverage and as a wedge. It should be regarded as something that varies in efficiency according to the way it is used and according to its specific features such as length, mass, material, etc.

(2) These experiments suggest that to assure flexibility in the use of tools Ss need to be faced with a number of problems with a limited number of tools.

Birch and Rabinowitz [2] in a rather well controlled experiment found that familiarization with a stimulus function of an object had a tendency to preclude the selection of that object for a different stimulus function in a novel problem. The string problem of Maier's was used. Results suggest that flexibility may be promoted by exercises in creating novel uses for everyday objects and to reward unusual but meaningful suggestions.

Educational Implications. (Same as for Duncker's study and Adamson's work.)

Kounin's [8] concept of rigidity is somewhat different from most other researchers interested in the phenomenon. His special definition is derived from psychology similar to the position of Lewin [22]. An individual is conceived as a dynamic system of forces interacting with his physical environment in a field called life space, which is structured according to certain psychological laws that can be stated by and large in the mathematical language of topology. Apparently, the mental self is composed of functional regions which exist in varying degrees of isolation. If the boundaries between functions are permeable and resilient such that interaction among the functions can easily occur, then, S is flexible. Examples of flexibility would include: (1) A ready recognition of relationships in a problem context, and (2) a high degree of transfer of learning, both positive and negative. These considerations logically lead one to the curious position of accepting perseveration as flexibility instead of rigidity. Most other psychologists think of perseveration and rigidity as similar if not synonymous. In Kounin's terms transfer always seems to denote *lack* of rigidity even when the transfer is negative. One form of negative transfer is perseveration. Therefore, perseveration is a sign of flexibility. A rigid person enjoys an advantage over the flexible one in situations where learning experiences tend to generate negative transfer.

Kounin used three groups of feeble-minded persons, adults, adolescents, and children, all having about the same I.Q.s. He had them draw a simple object until they developed no interest to continue. They were then asked to draw other objects repeating each one as much as they wished. The idea was to determine what effect the satiation of drawing one object had on the satiation of subsequent drawings. A group of normal children was also used.

Results: (1) Satiation had least effect on adult feeble-minded, i.e., they would continue to draw objects longer after having been satiated in drawing other objects.

(2) Normal Ss tired more quickly after having been satiated on the first drawing. They also spent the most time in non-drawing activities.

Another experiment involved the operation of a marble dispensing machine. The control lever could be either raised or lowered. Data were in terms of the number of times Ss shifted from lowering the lever to raising it or vice versa. Results indicated that adult feeble-minded Ss persisted longer in operating the machine in the same manner before changing. Normal Ss varied the most.

A third experiment which required rapid shifting in a sorting task found the adult feeble-minded Ss making the most errors and the young feeble-minded significantly fewer.

A fourth experiment required Ss to sort cards by finding common elements for classification. The task amounted to a test of mental integration through concept formation. Adult feeble-minded Ss performed least satisfactorily, with normal Ss superior to all other groups.

A fifth experiment using a similar task

indicated that adult feeble-minded Ss showed the least ability to make appropriate shifts.

Educational Implications. (1) Educable feeble-minded children (I.Q.s about 70 to 90) reach intellectual asymptotic limits much sooner than normal children. After the growth limit has been reached rigid behavior becomes more pronounced. Therefore, educators should take full advantage of establishing as much flexibility as possible prior to the leveling off of the curve.

(2) Older feeble-minded persons have much more resistance to monotony than younger feeble-minded ones and normal persons. Therefore, vocational guidance should exploit this knowledge because high grade morons may be actually more efficient than normal persons in simple tasks requiring sustained repetition.

Using the Wisconsin Card Sorting Test, Ross et al. [16] set up controls so that the basis for correct sorting was changed from color to form to number through verbal reinforcement. Several stress operations were invoked such as electric shock, heckling, and other auditory distractions. Combinations were used so that eight stress conditions were obtained. Results indicated that:

(1) Electric shock proved to be the most disturbing to efficient shifting.

(2) Ss could adapt to certain stresses such that he could reduce rigid behavior after becoming habituated to the conditions.

(3) Ss recovered quickly from the effect of shock.

Educational Implications. (1) The study suggests that humans learn to adjust rather effectively to a large variety of stress conditions. The negative effect of stress, and the length of time it endures, is probably a function of the kind of stress and the intensity of the stress.

(2) The electric shock was the most effective distractor and was the only variable which seemed to produce significant effect on total scores. Why? One rather probable reason is that shock was the only distractor that was used discontinuously, i.e., S could not learn the cues which signaled shock because no systematic guess was feasible. In animal experimentation, namely, when aperiodic punishment is used where the animal cannot learn what cues immediately precede punishment, there is much more sustained effect of anxiety. The important educational implication is that when the instructor reproves the student it should be quite clear to the student why the reproval is given. Unless such is made clear, S may show sustained anxiety which may increase rigid behavior.

(3) The extent Ss look upon tests as some kind of punishment may be related to the effect of pop quizzes on these Ss. Hence, the answer to the question "what is the effect of pop quizzes on learning efficiency" may have no single answer, but may be related to what attitude S takes toward tests.

(4) When students are made overly anxious about their chance of obtaining a certain level of success in the course, the probable increase of rigidity in problem solving and critical thinking is only one among several effects.

Cowen [5] varied the intensity of stress from "mild" to "strong" and administered Luchins' "Einstellung" test to see what effect different intensities of stress would have on perseveration. Control Ss did not work under stress.

Results: (1) Ss working under strong stress made more rigid responses than those under mild stress. Control group showed least rigidity.

(2) Time required to solve the problems was greatest for strong stress group and least for control Ss.

(3) Mild stress group had significantly more favorable attitude toward the test situation than the strong stress group.

Educational Implications. When S feels that his personality is being devaluated he will probably show a tendency to confine his behavior to responses that will protect him from further devaluation. This means that his behavior will probably be conservative and rigid in the sense that

he will be unwilling to "stick his neck out" and run the risk of being criticized. In the schoolroom, the strict disciplinarian (authoritarian) tends to repress the behavior of those Ss who have been reproved, except those with certain extreme characteristics.

Possible Positive Effects

(1) Cause Ss to work harder in preparation of lessons. (But the motivation is from an extrinsic pressure rather than from intrinsic interest.)

(2) Less classroom chaos.

Possible Negative Effects

(1) Increased rigidity

(2) Increased fear

(3) If instructor is disliked there may be a strong motivation to dislike the course (generalization phenomenon).

(4) Decreased amount of overt responding.

CRITIQUE AND SUMMARY

The problem of experimental control often leads to such delimitation that the study has the appearance of insignificance. Hence, it is understandable to find many educators favoring research from the personality approach, which often appears more strategic than learning experiments. But the interpretation of "strategic" is difficult. How much error can be tolerated before a study ceases to be strategic? Is a study strategic if it fails to support some hypothesis or fails to supply grounds for an important generalization? In the opinion of the writer, most test correlation studies about rigidity are only "pseudo-strategic." In other words, it is easier to over-rate correlation research than experimental work.

We saw in the previous paper that it was difficult to draw clear-cut conclusions from the correlations studies taken as a whole. Some of the research indicated that rigidity is a general personality trait and perhaps slightly more studies suggested that there was no basis for generalized rigidity. Perhaps a number of reasons could be given for the lack of agreement. Not the least among the reasons is that different tests of rigidity were used. Correlations between tests of rigidity varied between —.15 and .85. Perhaps the most serious omission among the correlation studies is determining the relation between paper and pencil tests and other behavior.

Correlation studies seem to have a lack of *direct* implication on what the teacher can do to increase mental flexibility and decrease rigidity in problem solving. The reason for this, as mentioned before, is that the results of test correlation studies are not expressed in terms of dependent and independent variables, but only as relations between dependent variables or test behaviors (scores). When test scores are expressed as a function of conditions imposed upon S, then the study takes on the garb of experimentation, which usually changes the research question from "what" to "how." The experimental answer to "how" is determined by showing that certain conditions predispose a particular result, e.g., that severe punishment in an unsolvable problem situation increases rigidity. Correlation of test scores does not get at the "how," i.e., does not relate conditions to behavior but relates behavior to behavior. Here are some conditions and operations which seem to increase mental rigidity as suggested by the learning experiments: (1) Pronounced negative reinforcement or personal threat, (2) a psychological set for speed, (3) lack of preparedness in a "real life" problem situation, (4) authoritarian behavior on the part of the teacher, (5) lack of maturation, (6) increased effort, (7) partial reinforcement, (8) massed practice, (9) rote practice, (10) non-differential reinforcement, (11) lack of repeated orientation toward the advantages of flexibility, (12) a non-varied experience in the use of tools, (13) verbal expression by S of a low attitude toward the problem, (14) docile behavior toward

the teacher or experimenter, (15) lack of variation in the stimulus complex (when stimulus was altered radically rigidity decreased), (16) lack of up-to-date self evaluation, (17) brain injury, (18) repeated punishment in a rather stable stimulus complex, (19) actions on the part of parents and teachers that stifle imagination through ridicule or physical threat. There was relatively little contradiction in the studies concerning the above points. On the other hand, there was less apparent duplication than in the personality studies, which were largely concerned with the generality of rigidity. In any event, taken as a whole these learning studies appear to be quite strategic, while personality studies, taken as a whole, offer a rather confused picture.

The main difference in the results of the two approaches seems to be that the personality type studies are *hypothesis producing* rather than hypothesis testing, while learning experiments tested as well as produced hypotheses. Perhaps the most useful place for tests is in the experimentation situation where changes in test scores are noted as a function of measured conditions.

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AN EXPERIMENTAL STUDY APPLYING NON-ARISTOTELIAN PRINCIPLES IN THE MEASURMENT OF ADJUSTMENT AND MALADJUSTMENT [1]*

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IN any society one can find individuals ranging in a continuum from the completely adjusted to the totally maladjusted. The problem of the social adjustment or maladjustment of its individuals is and has been one of the most fundamental for all cultures. The division of the adjusted from the maladjusted is usually an arbitrary or legal line. Those in the former category are usually the happiest and most useful members of the group, while those in the latter are often unhappy nonuseful or even dangerous, against whom society may protect itself by confining them in institutions. The treatment of the symptom rather than the treatment of the cause has probably been due to lack of understanding of the underlying reasons for the lack of adjustment.

Alfred Korzybski proposed over twenty-two years ago that maladaptive language habit patterns might contribute to maladjustment. In his monumental work, "Science and Sanity," he suggested that one of the major reasons why science has progressed is because scientists use a language structure that corresponds more nearly with the structure of the real world, and that many other disciplines, notably philosophy, have not progressed for the reason that these other disciplines continue to use a language whose structure implies a static rather than a process reality. Korzybski suggested that so long as man continued to accept Aristotle's laws of thought as laws of nature he would operate in an inflexible prescientific manner which was maladaptive and hence contributive to maladjustment. He insisted that Aristotle's laws of thought were false to empirical fact, and that while such laws were convenient for words they were not convenient for process reality, which after all is what organisms must ultimately adjust to. Specifically, he pointed out that any form of the verb "to be" which identifies the label with the thing labeled is of necessity misleading, unless one is conscious of the part one's own nervous system plays in the process when such identification is made. For example, early man, the man of Aristotle's day who knew little about nervous systems, saw a leaf and the physiological reaction which he experienced was given a label. He, therefore, on the basis of his limited information, and unaware of the part his eye, the optic nerve, and his brain played in the process said "The leaf IS green," describing the green as a property possessed by the leaf. The greenness, however, was a joint phenomena between that which was being observed and the observer.

A discipline arose out of Korzybski's work now known as General Semantics based on the premise that the structure of language which men expect to deal with and to describe the process world around them should be similar in structure to the process world. OR, if the similarity of structure is lacking, the men who use the language should be aware of its limitations which can lead them into pitfalls of misunderstanding and misevaluation. This study points to the "IS of identity" as one of the limitations. If its unthinking use can lead to misunderstanding and misevaluation, then it may be both a precursor and a symptom of maladjustment.

Prior to this study, no attempt had been

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made to test this hypothesis.[2] The question thus arose in the mind of this investigator as to how such a test might be made. The idea of a paper and pencil test composed of items embodying the "IS of identity" appeared possible, and the scores earned on such a test compared with a subject's social adjustment could substantiate, to a degree, the claim of the general semanticists OR refute it. If the study substantiated the claim that the "IS of identity" contributes to maladjustment, and if additional studies continued to support the claim, the results could have widespread significance, particularly in the language training of school children.

Hundreds of items were collected embodying the "IS of identity" (i.e., "exercise is good") and groups of these administered to one population after another each time retaining the best items, that is, the items which discriminated between high and low scorers to the greatest degree. During the selection of items no distinction was made as to the adjustment of the students involved. Finally, one hundred highly discriminating items were selected. The next task was to find some criterion against which these might be correlated. It was decided that some pilot studies should first be run in order to determine if the results justified a larger study. For these, teacher rating was to be used as the basis for making a judgment as to the student's social adjustment against which scores earned on the "IS of identity test" could be correlated. Fifty students were selected at random — twenty-five girls, twenty-five boys. Each of these students was rated by three teachers. The test was administered and a simple correlation between social behavior as evidenced by teacher ratings and scores on the test was made. The correlation was plus 0.47. A correlation between intelligence quotients and test scores was plus 0.03.

Although the sample was small, the results seemed to indicate that whatever the test measured, it was more closely related to social adjustment than to intelligence. Another study was made with fifty other students, approximately the same results obtained. Both of these pilot studies were made with high school students between grades seven and twelve. The test was then administered to a group of forty graduate students at Michigan State College, and while no attempt was made to determine the ability of the test to discriminate between the well adjusted and poorly adjusted, the test demonstrated its discriminating power between high and low scorers to the same degree as it did with a high school population.

The final pilot study was with a group of 100 delinquent boys serving time in a Lansing penal institution. In this study once again there seemed to be a much closer relationship with social adjustment than with intelligence and most revealing was the obvious difference in means between the institutional group and the one hundred students previously tested who were not institutionalized.

The results from the three pilot studies seemed to justify a larger study. It was decided that the sample should consist of 250 individuals in correctional institutions and 250 students in the Lansing Public Schools. These latter should be randomly selected with approximately the same number of boys and girls. The institutionalized group was comprised solely of boys.

The following data were entered for all testees: age, sex, church attendance, church affiliation, I.Q. score, score earned on the test, and, for the noninstitutional group only, teacher ratings. The teacher rating was a composite by several teachers on each student, and ranged from 4 (poorly adjusted) to 1 (very well adjusted).

Reliability was determined by first making an item analysis. This permitted equating two halves of the test by including parallel items of equal difficulty in each of the halves. The correlation thus obtained indicated the reliability of a test of fifty items. Reliability on the full length test

[2] Lee, Irving J. "General Semantics 1952," *Quarterly Journal of Speech*, 39:1–12.

was determined by the Spearman Brown prophesy formula and was found to be 0.94, which closely approximated the reliability found in each of the pilot studies.

Validation of the test was accomplished by comparing by correlation and analysis of variance or analysis of variance with covariance adjustment teacher ratings with "IS of identity" test scores for those in the out-of-institution group, and by comparing by analysis of variance the "IS of identity" test scores of the total out-group with "IS of identity" test scores of the total in-group.

Analysis of variance showed that test score variation could not be reasonably associated with sex differences, age differences, or church attendance or nonattendance; however, there was significant differences between Catholic-non-Catholic categories.

A correlation between teacher ratings and "IS of identity" test scores (Table I) showed highly significant relationships, while a correlation between teacher ratings and intelligence quotients was nonsignificant (Table II). However, when a correlation was made between intelligence and "IS of identity" scores, significance approaching the 0.05 level was found. This necessitated the use of covariance adjustment to limit the influence of I.Q. in the analysis where significance was found. Applying covariance adjustment did not alter the finding that no difference exists between scores earned by boys and girls, but the significant difference between Catholic-non-Catholic categories became non-

TABLE I

CORRELATION BETWEEN "IS OF IDENTITY" TEST SCORES AND TEACHER-RATINGS AT EASTERN, SEXTON, AND WALTER FRENCH SCHOOLS

	N	Sum of Teacher Ratings	Sum of Test Scores	(Sum of Teacher Ratings)^2	(Sum of Test Scores)^2	Sum of Cross Products	Correlation Coefficient	Sig. Level
Eastern	100	259	5,141	741	288,894	12,489	−0.63	0.001
Sexton	85	245	4,614	765	237,112	12,660	−0.55	0.001
Walter French	48	131	2,175	393	108,935	5,656	−0.46	0.001

TABLE II

CORRELATION IQ-T.R.

Schools	N	ΣIQ	ΣT.R.	ΣIQ^2	T.R.^{2}	Σ(T.R.)(IQ)	Coefficient of Correlation r
Sexton	85	8,965	247	968,189	773	25,919	−0.12*
Walter French	48	5,170	129	565,832	363	13,876	−0.05*

* Not sig.

TABLE III

ANALYSIS OF VARIANCE (WITH COVARIANCE ADJUSTMENT) AND TEST OF SIGNIFICANCE. "IS OF IDENTITY" TEST SCORES—CLASSES (INS, OUTS)

	Total	Within	Between
Sums of products xy	51,082	36,445	14,637
Sums of squares of x's	143,739	122,490	21,249
Sums of squares of y's	122,165	101,719	20,446
d.f.	514	513	1
Adjusted Σx^2	122,380	109,422	12,958
d.f.	513	512	1
M.S.		213.71	12,958

$F = 60.6$ (highly sig.)

significant. The highly significant difference between institutional versus noninstitutional groups remained (Table III), as did the highly significant difference between teacher ratings and test scores (Table IV).

TABLE IV

ANALYSIS OF VARIANCE (WITH COVARIANCE ADJUSTMENT) AND TEST OF SIGNIFICANCE. "IS OF IDENTITY" TEST SCORES—CLASSES (TEACHER-RATINGS)

	Total	Within	Between
Sum of products xy	15,757	9,662	6,095
Sum of squares of x's	56,969	38,664	18,305
Sum of squares of y's	51,595	48,957	2,638
d.f.	224	221	3
Adjusted Σx^2	52,157	19,595	32,562
M.S.		89.07	10,854.00

$F = 121.85$ (highly sig.)

While it would be desirable to have further confirmation of the results, their significance, at present, seems to be considerable. This is based on the finding that institutionalized boys (thereby classified as maladjusted by society) do use the "IS of identity" to a greater degree than do those not institutionalized, as evidenced by a lower mean score on the "IS of identity test." The consistency between teacher ratings of social adjustment and scores earned on the "IS of identity" test provides further foundation for the conclusions of the validity of the test and interconnection between "IS of identity" and degrees of adjustment. The lesser the use of the "IS of identity" the better the teacher rating and conversely the greater the use of the "IS of identity" the poorer the teacher rating.

It would seem that the test developed in this study gives, in the mean, a satisfactory indication of the social adjustment or maladjustment of an individual and that, therefore, a person's use of the "IS of identity" is connected with his degree of adjustment to society.

The results of this study seem to further imply that the principles of general semantics which underlie this investigation are sound; that the reasoning based on these principles is correct, namely that when the structure of the language used by an individual is dissimilar to the structure of the real world and the individual is unaware of the dissimilarity, it can lead him into misevaluations and consequent maladjustment.

The implications for elementary education or preschool home education arise from the finding that for the range of age covered in this study (13–24), no variation of the "IS of identity" test scores was found. This seems to imply that the individual's language-habit patterns had become fixed at age levels much below those studied here. This suggests that measures aimed at the prevention of maladjustive language-habit patterns should be undertaken at elementary or preschool-age periods.

The implication for education beyond elementary years is that at higher levels the "IS of identity" test can be used to determine which individuals are in need of remedial treatment aimed at a development of an awareness of their language-habit patterns. Such remedial training would enable those discovered to avoid misevaluations, and hence to increase their adjustment to society or the process world as a whole.

The implication for teacher and counselor training is that if they were trained in the principles of general semantics, not only would their own professional orientation be improved, but it would enable them to apply the test and to undertake the remedial measures necessary.

The implication for general democratic living is that were it possible to develop

an awareness in the total population of the dissimilarity between the language structure and process reality, it might decrease enormously the maladjustment in our society. Our language appears to reflect a static concept of "reality." Identification seems to contribute to this static reflection. Teaching the individual character of all things, processes, and events might aid in the awareness of process reality and might contribute to the development of a more flexible, dynamic, multioriented individual, who in turn might well be a less likely candidate for institutional life.

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A STUDY OF ACADEMIC PREFERENCES AND THEIR APPARENT RELATION TO STUDENT CHANGE IN A PROGRAM OF GENERAL EDUCATION—WITH PARTICULAR REFERENCE TO STUDENTS IN THE VARIOUS SCIENCE AREAS *

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THE purpose of this study was an attempt to study the factor of change in students over a period of one year when considered in the light of their own major interest areas. Particular emphasis was given to the students in the various areas of scientific study—and to a comparison between their change or achievement and the achievement of students in the other "non-scientific" areas.

This matter of change may be considered as one of the bases of the entire educational process—for the purpose of education is to guide students from wherever they may happen to be toward some specific objective or goal. However, while there is usually little question about this basic assumption, questions are frequently raised concerning the actual process of change, such as "How successful is this or that technique?" or "How does this or that factor affect the process of change?"

There have been many attempts to answer these and other related questions utilizing many different approaches. One such approach, making use of objective tests administered before and after a particular educational experience, has been used in this study. Here the particular educational experience being evaluated is the effect of one academic year of college

* Paper presented at the Twenty-Eighth Annual Meeting of the National Association for Research in Science Teaching, Teachers College, Columbia University, April 19, 1955.

work in a program of general education, with particular attention to the students' major areas of interest or "stated area of intended specialization."

Since academic ability or achievement in the subject matter areas is regularly measured and evaluated by the usual testing techniques, it was decided to direct this research to other facets of student growth not normally tested. These areas were those of (1) Beliefs, Reactions and Attitudes in general; (2) Ability to do Critical Analysis in Reading and Writing; and (3) Critical Thinking. Interests were selected as the variable to be studied because it was believed that in selecting a particular area of study or preference as an intended "Major," a student is doing more than merely choosing an area of specialization. It was hypothesized that the student is, in an indirect manner, indicating several facets of his personality make-up and his concepts of his place in society. He is actually selecting, along with his future profession, such things as the stratum of society to which he aspires and the degree of socialization he desires in his work, as well as demonstrating such things as the relative importance to him of the material versus the non-material aspects of our culture. Hypothesizing that these concepts are true, it was expected that, if students could be grouped according to these intended "majors" or areas of interest, they could be expected to show differences that are distinctive between each other. It was further expected that these differences could be extended to such areas as Ability to do Critical Analysis in Reading and Writing, and Critical Thinking, as well as to the area of Beliefs, Reactions and Attitudes in general.

The instruments used in this study were (1) *The Test of Critical Thinking,* Forms A and B; (2) *The Test of Critical Analysis in Reading and Writing,* and (3) *The Inventory of Beliefs.* These had been developed by the committees of the Co-operative Study of Evaluation in General Education of the American Council on Education during the previous two years. The *Critical Thinking Test,* an instrument of fifty-seven items stated as objective-type test questions, was designed to measure the capacity of college freshmen and sophomores to demonstrate the following abilities:

1. Ability to define problems (to recognize evasions and to select the most inclusive statements of relative factors).
2. Ability to select pertinent information for the solution of problems.
3. Ability to recognize unstated assumptions.
4. Ability to select relevant and promising hypotheses.
5. Ability to recognize the structure of an argument, to make valid inferences, and to distinguish valid from invalid inferences.

The *Inventory of Beliefs,* an instrument consisting of 120 statements with which students are expected either to agree or to disagree, provides opinionaire evidence on the statements themselves, and also yields, as a total score, an index of certain aspects of personality structure.

"The fundamental assumption underlying the *Inventory of Beliefs* is that the objectives of general education can serve as a base from which may be inferred the model organization characterizing the personalities of those most adaptable to the purposes of general education." [1]

The first part of the *Test of Critical Analysis in Reading and Writing* presents students with three passages dealing with the subject of the good life. These passages, drawn from Thoreau's *Walden,* from the *Rubaiyat,* and from the "Sermon on the Mount," are followed by questions requiring the student to make comparisons between the three points of view expressed in the three passages. In the second part of the test, the students are presented with an exact reproduction of a student theme comparing the three points of view, and are then asked questions concerning the general writing ability demonstrated in the theme.

[1] Cooperative Study of Evaluation in General Education, *Instructors Manual for the Inventory of Beliefs,* American Council on Education, 1950, p. 4.

These tests were first administered in September, 1951, to 1,942 Freshman students entering Michigan State College, and given again during the last week of the Spring Term, 1952, to a re-test group of 569 students, comprising a representative sample of the initial group tested, and also of the entire freshman body. This representativeness was established on the basis of the students' "Quantitative," "Linguistic" and "Total" scores on the American Council on Education Psychological Test. For this purpose the Chi-square test of *goodness-of-fit* was used. That is, the frequency distribution of the final working sample was checked to see whether, within the limits of chance sampling, it was of the same type, or could be fitted to the frequency curves obtained from the data for the initial group tested and also for the entire freshman population.

RESULTS

The first objective was to determine whether any significant change or gain over the period of the academic year could be discovered, for the entire student body, in each of the areas tested. The *"t"-test of significance* between pre- and post-test means was used here. The results showed a significant change or gain in each of these areas.

The pre- and post-test total group means, as well as the obtained values of "t" for each of the three test instruments were:

Test	Pre-Test Mean	Post-Test Mean	Obtained Value of "t"
Inventory of beliefs	56.4552	63.4060	15.2580
Test of critical analysis in reading and writing	14.5132	18.3058	19.2264
Test of critical thinking	31.8711	39.0941	18.7856

For the "t"-test of significance between the means of pre- and post-test scores, and with 568 degrees of freedom, the required value of "t" at the 1 per cent level of confidence would be 2.568. From the results given it will be immediately apparent that a significant difference exists between the total group means of the pre- and post-test scores in all three areas measured!

The second objective was to attempt to discover whether the significant differences could be distinguished *between* the change or gain of students in various interest groups, within each of the three areas examined. The *Analysis of Variance* (by *Covariance Adjustment Technique*) was used for this purpose, with the pre-test or initial scores, and scholastic aptitude as measured by the A.C.E. Psychological Examination as considered variables. A comparison, or ranking, of the adjusted post-test means was also made.

The students were divided into the interest groups shown, according to their indicated field of preference, or "major." These areas were:

Science Areas:

1. Biological and Physical Science
2. Engineering
3. Pre-medical, pre-dental, pre-veterinarian, and pre-nursing
4. Agriculture and Forestry

Non-Science Areas:

5. Business Administration and Hotel Administration
6. Home Economics
7. Fine Arts
8. Elementary Education
9. Language and Literature
10. Social Science and Social Service
11. No-Preference

The smallest "N" in any of the groups was sixteen in the Fine Arts group, and the largest was 161 in the No-Preference group. This last group is made up of students who have not yet decided upon an area of interest or "major," and can in fact be considered as being composed of students who will eventually go into all of the other areas. In this connection it is interesting to note that, as might be expected, in the analysis of the results this group ranked close to the mid-point in all of the areas measured.

Inventory of Beliefs

In the area measured by the *Inventory of Beliefs*, significant differences at the 1

per cent level of confidence were discovered between the changes or gains of students in the various interest categories.

Coefficients of Correlation "r" *between* the A.C.E. Psychological "Total" score and

	For Total Group	Within Groups
Inventory of Beliefs *Pre-Test* Scores	.17979	.18575
Inventory of Beliefs *Post-Test* Scores	.20081	.20256

An *Analysis of Variance (by Covariance Adjustment technique)* of the *gains* of the students in the 11 different interest categories showed that significant differences exist at the 1 per cent level of confidence between the gains of the various groups. ($F = 2.8089 > 1\%$ level $= 2.36$)

Test of Critical Analysis in Reading and Writing

In the area measured by the *Test of Critical Analysis in Reading and Writing*, significant differences at the 1 per cent level of confidence were discovered between the changes or gains of students in the various interest categories.

Coefficients of Correlation "r" between the A.C.E. Psychological "Total" score and

	For Total Group	Within Groups
Test of Critical Analysis in Reading and Writing *Pre-Test* Scores	.4213	.4247
Test of Critical Analysis in Reading and Writing *Post-Test* Scores	.4357	.4586

An *Analysis of Variance (by Covariance Adjustment technique)* of the gains of the students in the 11 different interest categories showed that significant differences exist at the 1 per cent level of confidence between the gains of the various groups. ($F = 6.4589 > 1\%$ level $= 2.36$)

Test of Critical Thinking

In the area measured by the *Test of Critical Thinking*, however, *no* significant differences were detected at the 5 per cent level of confidence between the changes or gains of the students in the various interest categories.

Coefficients of Correlation "r" between the A.C.E. Psychological "Total" score and

	For Total Group	Within Groups
Test of Critical Thinking *Pre-Test* Scores	.46858	.46422
Test of Critical Thinking *Post-Test* Scores	.48084	.49006

An Analysis of Variance (by Covariance Adjustment technique) of the gains of the students in the 11 different interest categories showed that *no* significant differences exist at the 5 per cent level of confidence between the gains of the various groups. ($F = 1.7207 < 5\%$ level $= 1.91$)

Table I shows a ranking of the "scientific" and "non-scientific" interest groups, according to their Post-Test Mean Score, after adjusting for performance on the pre-test and on the A.C.E. Psychological Examinations. This adjustment technique compensates for whatever initial differences may have existed between the various groups insofar as pre-test performance was concerned, as well as for differences in scholastic ability as they are indicated by the A.C.E. "Total" Score.

Since no significant difference was discovered *between* the gains of the various interest groups in the area measured by the *Test of Critical Thinking*, no ranking has been given for that area as it would lack real or statistically significant meaning.

Considerations of the Results

The first point which may be noted is that for the entire student body considered as a single group, significant differences were discovered between pre- and post-test means for all three areas measured. This may be interpreted as an indication that on the whole, exposure to the Freshman year program does appear to give rise to a significant change or gain in the areas of

TABLE I

COMPARISON OF ADJUSTED POST-TEST MEANS AFTER PRE-POST TEST PERIOD OF ONE ACADEMIC YEAR

Interest Group Categories	Test of Critical Analysis in R&W		Inventory of Beliefs	
	Rank*	Adj. Post-Test Means	Rank*	Adj. Post-Test Means
"Science Areas"				
Biological and physical science	6	17.9154	1	71.768
Engineering	11	14.8376	9	61.068
Pre-medical; pre-dental; pre-veterinarian; pre-nursing	4	19.1837	11	60.173
Agriculture and forestry	2	19.4007	6	63.743
"Non-Science Areas"				
Business and hotel administration	7	17.8839	8	61.488
Home economics	1	21.7939	2	66.932
Fine arts	3	19.3954	4	65.211
Elementary education	8	17.8368	10	60.650
Language and literature	9	17.5663	7	62.502
Social science and social service	10	15.4297	3	66.827
No-preference	5	18.8600	5	64.532

*Rank: Refers to standing of adjusted Post-Test Mean Score when compared with Post-Test Mean Scores of other groups.

Critical Thinking; Ability to do Critical Analysis in Reading and Writing, and Beliefs, Reactions and Attitudes in general.

This, of course, is what was expected for these are areas to which much concern and attention are given in the program of the Basic College at Michigan State College, and since all the students had been exposed to this program for the entire academic year, such new evidence while gratifying was not too surprising.

What was of considerable surprise and interest was the result of the study of the individual interest areas or categories. Possibly the most unexpected result was the discovery that no significant differences could be detected between the changes in the area of Critical Thinking between either the "Science" versus the "Non-Science" groups, or between those in any of the separate interest areas. This suggests that all students seem to profit equally in this area, regardless of their specific interests.

However, this does not apply to the area of achievement measured by the *Test of Critical Analysis in Reading and Writing.* Superficially, after a preliminary examination of the test material, it might be expected that the results would be biased in favor of the "Non-Science" areas, and in particular the *Languages and Literature* group of students, since the materials upon which the questions are based seem to bear the same cultural bias, i.e., Thoreau's *Walden,* the *Rubaiyat,* and the "Sermon on the Mount." The obtained results, however, show that this is not the case, for the greatest amount of change was achieved by both "Science" and "Non-Science" groups, that is, by the *Agriculture and Forestry,* and the *Pre-medical, pre-dental, pre-veterinarian,* and *pre-nursing* groups. The *Language and Literature* group ranked among the three groups showing the least amount of change, along with the *Social Science and Social Service* group, and the *Engineering* group.

An examination of the raw scores of pre- and post-test results revealed much the same pattern of results. It then becomes increasingly difficult to accept either the concept of cultural bias in the test material, or that of "innate" differences between students in the "Science" and "Non-Science" areas.

Turning now, for the moment, to the results of the comparison of gains for the *Inventory of Beliefs,* similar interesting but provocative factors can be observed. In addition to its ability to detect and measure change, because of the nature of its structure, the *Inventory* is designed to assist in the identification of students who tend to accept stereotypes, who are rather dependent and rigid in their attitudes and beliefs. However, it is a rather difficult task to discuss or to attempt to rationalize the relationship between these purposes of the test instrument and the obtained result.

Again here, there does not appear to be any difference between the achievement of "Science" and "Non-Science" students. The greatest amounts of change were made by the *Biological and Physical Science* group, the *Home Economics* group, and the *Social Science and Social Service* group. The three groups showing the least amount of change were the *Engineering* group, the *Elementary Education* group, and the group composed of the *Pre-Medical, pre-Dental, pre-Veterinarian* and *pre-Nursing* students.

It might be assumed that students interested in the "Science" areas, such as *Biological and Physical Science, Engineering* and the pre-professional groups could be expected to be imbued with what is often loosely referred to as the "scientific approach," and consequently could be expected to make the greatest change over the period of one year in the area of beliefs, reactions and attitudes in general. However, this appears to be true only for the first-named group.

A possible explanation, which might also account for the high achievement of such "Non-Science" groups as *Home Economics* and *Fine Arts,* as well as the relatively poor showing of such "Science" groups as *Engineering* and *pre-Medical, pre-dental, pre-nursing* and *pre-veterinarian* students, might possibly be found by an examination of the curricula in the respective areas. Such a review seems to show that a greater degree of similarity than might ordinarily be expected exists between the *Biological and Physical Science* curricula on the one hand and the *Home Economics, Fine Arts,* and *Social Science and Social Service* curricula on the other. All show a rather high degree of flexibility, with considerable encouragement for the development and exercise of individual judgment. Experimentation, constant re-examination of ideas and theories, etc., are stressed in many different ways. This apparently encourages the growth of individualism, and a willingness to try out new and different ideas, and develops a more self-reliant individual than some of the other curricula. On the other hand, it would appear that the student in the more inflexible and rigid curricula such as Engineering and the pre-professions are those who gain least from a year's exposure to a program of general education.

At this point it is rather a temptation to derive some implications for programs of education from the results already obtained. However, except for the rather obvious suggestion that educators ought to begin to pay more attention to the areas in which a student evinces interest, and to develop at least some aspects of such courses as English Reading, Composition, etc., around these interest areas, it would probably be wiser not to yield to the temptation at the present time. A follow-up study of these students is now being carried out. When the final reports on their achievements, changes in program, and success or failure in college over the whole four-year period are completed, it may be possible to make more definitive conclusions and recommendations.

PER CENT OF STUDENTS TAKING EACH BASIC COURSE, OMITTING EACH BASIC COURSE, AND ACCELERATING IN EACH BASIC COURSE ASSOCIATED WITH EIGHT CURRICULUM AREAS AT MICHIGAN STATE UNIVERSITY

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In 1950 studies were completed [1] showing accelerated students in Biological Science at Michigan State College make higher grades in advanced biology courses than do non-accelerated students. This was true even when achievement at the beginning of the advanced courses, and general learning ability were held constant. The study created general interest in the question "Does this level of performance hold true for accelerated students in areas other than Biological Science"?

Upon suggestion of the late Dean H. C. Rather the project was extended to include all departments in the Basic College. The details of the cooperative investigation were worked out by consultation among representatives of each department.[2]

It is the purpose of this paper to present a statistical investigation [3] designed to gather evidence concerning the relationship of Basic College students to the various basic courses at Michigan State College. A follow-up paper is planned on the "Predictability of Success in College Courses by Accelerating and Non Accelerating Students as Measured by Scores Made by Entering Freshmen on A.C.E. and Cooperative Reading Test."

[1] Van Der Jagt, E. R., "Performance of Basic Biological Science students in advanced Biology courses," *Science Education*, Vol. 34, March 1950, No. 2, p. 85.

[2] People cooperating in the project: C. M. Babcock—Written and Spoken English—Basic 111, 112, and 113. *E. R. Van Der Jagt—Biological Science—Basic 121, 122, and 123. J. W. Zimmer—Physical Science—Basic 131, 132, and 133. J. O. Hall—Social Science—Basic 141, 142, and 143. †J. B. Holland—Effective Living—Basic 151, 152, and 153. †M. K. Farmer—History of Civilization—Basic 161, 162, and 163. V. E. Leichty—Literature and Fine Arts—Basic 171, 172, and 173.

[3] A grant from the All-College Research Fund was provided for some of the labor involved in gathering the data.

* Coordinator and Leader.

† Deceased.

TYPES AND SOURCES OF DATA

From the record files of the Registrar, the Board of Examiners, and the departments concerned, the following data on several hundred seniors were gathered:

1. Performance on the American Council Psychological Examination.
2. Reading performance. (Cooperative Test of Reading Performance.)
3. Senior grade point average, with and without acceleration grades.
4. Performance on a comprehensive examination in each Basic taken.

Each Basic College course consists of three sequential terms of study which are hereafter referred to as Terms 1, 2, and 3.

Students who attained sufficiently high departmental test scores and who demonstrated daily ability in the course to the instructor during the first term, or for terms 1 and 2, were allowed to accelerate their programs by taking the comprehensive examination without completing all three terms.

There were seven Basic College courses, which will be identified as given in the following list:

111 Written and Spoken English
121 Biological Science
131 Physical Science
141 Social Science
151 Effective Living
161 History of Civilization
171 Literature and Fine Arts

In consultation with the chairmen of the Basic College departments, a list of eight curriculum areas was drawn up including at least one closely related to each basic course. These are given in the following list, together with identifying code numbers as used by the Registrar, and the numbers of the related basic courses.

Curriculum Number and Description	Related Basic Number and Description	Graduating Number of Senior Students in Curriculum
C 23—Phys. Ed., Health, and Rec.	121 Biological Science	30
C 25—Public Administration	161 History of Civilization	14
C 26—Social Service	161 History of Civilization	8
C 50—Fine Arts	171 Literature and Fine Arts	50
C 52—Language and Literature	111 Written and Spoken English	105
	171 Literature and Fine Arts	
C 55—Biological Science	121 Biological Science	47
C 56—Physical Science	131 Physical Science	18
C 57—Social Science	141 Social Science	126
	151 Effective Living	
	161 History of Civilization	

Senior graduating students associated with the previously mentioned course relationship constituted the eight curriculum groups. A ninth group was obtained by choosing names at random from a list of the graduating senior students in all other curricula. In all nine groups, transfer students and others for whom data were incomplete were dropped from the list and are not discussed in this paper.

The decile scores recorded on the students' permanent records are regarded as a measure of general college ability and general reading ability.

Grades at Michigan State College are of the traditional A, B, C, D, F type found on most campuses. Grade points conformed to the standard method of assignment: four grade points per credit for an A, three for a B, two for a C, one for a D and 0 for an F. Sub groups of all groups were roughly equated as to college ability by a random selection of an equal number of students from each rank (A.C.E.) and reading ability as determined by their rank in the reading test decile. These procedures for equating, sampling, and scoring were used throughout the total study.

Tendency of the Students to Accelerate Their Basic Program

There were two questions evident for which an answer was desired. (1) What sort of student accelerated and in what basic fields? (2) Are students in some curricula predisposed to accelerate, or is the basic course the decisive factor? Since each student was allowed to omit one or two of the basic courses, the percentage taking each basic also must be considered.

For the eight curriculum groups combined, the percentage of students accelerating in one basic or more was 46.7, or approximately 47. We now examine the corresponding percentage for each of the subgroups.

	Per Cent
More than Average Acceleration	
C 26, Social Service	62
C 25, Public Admin.	57
C 57, Social Science	55
About Average Acceleration	
C 52, Lang. and Lit.	47
C 55, Bio. Science	47
C 56, Phys. Science	44
Less than Average Acceleration	
C 50, Fine Arts	38
C 23, Phys. Ed., H. & R.	16

The deviations from the average prove to be statistically significant. Statistical analysis is discussed in section 1.

Next we show a further breakdown of the same data, as to whether the acceleration was in the related field (Rel.) or in a field not directly related (NDR) to the

curriculum. Since no basic courses could be singled out as related to the random sample, it is omitted from this discussion. For the entire group, the percentages were as follows:

	NDR	Rel.
	40.7	22.3
or approximately	41	22

If these percentages are added there is an apparent discrepancy with the percentage 46.7 previously given for the eight curriculum groups combined. It should be mentioned at this time that any student, having met the qualifications mentioned for any basic, could accelerate regardless whether the course was related or not related. Therefore some students had both related and non-related acceleration and were counted with both groups.

	NDR Per Cent	Rel. Per Cent
NDR High		
C 25, Public Administration	57	21
C 57, Social Science	52	21
C 26, Social Service	50	25
Rel. High		
C 55, Biological Science	38	32
Rel. High, NDR Low		
C 56, Physical Science	33	44
C 52, Language and Literature	36	32
Rel. Low		
C 50, Fine Arts	38	6
Both NDR and Rel. Low		
C 23, Physical Education, Health and Recreation	17	11

A statistical test applied to a modified form of the data and discussed in section 2 shows the existence of statistically significant deviations of the subgroups from the overall average.

While the curricular groups were found to vary significantly in amount of related acceleration, they are "related" to several different basic courses, and it is not evident from the preceding discussion whether differences in the basic courses involved are sufficient to account for the variation. We therefore examine the basic courses one by one, considering the following data for each: the number of students of each curricular group who enrolled, and of those enrolling, the numbers taking all three terms, accelerating one term, or accelerating two terms. If the ease or difficulty of accelerating in a given basic course is the major factor in determining a student's action, then we would expect the percentage accelerating to be about the same for all students in the basic, whether in a related curriculum or not. Any differences which students of different curricula display in their tendency to accelerate in the given basic can thus be traced to the upper school.

In the compiled summary charts below, two sets of percentages are given for each basic course:

E—The percentage of each group who enrolled in the course.
A—The percentage of those enrolled who accelerated.

Chi-square tests indicated that in several of the basic courses there were significant differences among curricular groups, both in percentage taking the course and in percentage accelerating. The differences and their statistical significance are discussed briefly in the table.

The foregoing data indicate that in most of the basic courses there were substantial differences in the performance of students from different curricular groups. It may be pointed out that Basic 111, Written and Spoken English, was required for all students, and no differences in enrollment could be expected. In two other basics, Physical Science, 131; and Literature and Fine Arts, 171; the small number enrolling limited the use of statistical analysis of percentages accelerating. It is possible that with more data significant differences would have been detected. The latter course devoted one term to each of the subjects literature, music, and art, and even a superior student might not have wished to accelerate at the expense of missing an entire area.

It was shown in an earlier section that for both Phys. Ed., Health, and Rec., C 23; and Fine Arts, C 50; the percentage accel-

TABLE I

Enrollment and Acceleration by Curricular Groups in Each of the Basic Courses
(Discussion in Section 3.)

Curr. Grp.		C 23	C 25	C 26	C 50	C 52	C 55	C 56	C 57	RS	Total	X^2 signif.
Size of group		30	14	8	50	105	47	18	126	61	459	
W&SE	E	100	100	100	100	100 R	100	100	100	100	100.0	No
	A	7	21	38	24	32	21	17	26	20	24.2	No
Remarks: Enrollment obviously uniform. Acceleration above average for related group C 52, but not enough to be statistically significant.												
Bio. Sci.	E	93 R	93	100	92	89	100 R	78	78	80	86.5	Yes
	A	11	23	38	2	11	32	21	30	10	18.1	Yes
Remarks: Enrollment low for C 56 and C 57. Acceleration low for C 54, very high for C 26, C 55 (related field) and C 57. RS and C 57 both low in enrollment but differ sharply in acceleration.												
Phys. Sci.	E	13	14	12	14	15	25	100 R	27	46	26.6	Yes
	A	0	0	0	0	12	8	44	26	25	22.1	No
Remarks: This basic avoided by all except C 56 and perhaps some groups within RS. Chi-square test on acceleration omitted on the related group C 56 because of small size of group.												
Soc. Sci.	E	97	86	100	66	81	81	83	98 R	85	86.3	Yes
	A	0	25	0	15	11	3	20	21	21	14.6	Yes
Remarks: Enrollment notably low for C 50, high for C 23 and C 26, as well as related group C 57. Acceleration low for C 23, C 26 and C 55.												
Eff. Liv.	E	100	57	38	62	72	83	61	82 R	75 R	75.6	Yes
	A	3	25	33	29	18	21	27	35	17	23.6	Yes
Remarks: Enrollment low for C 50, C 56, C 25, C 26.												
Hist. Civ.	E	90	100 R	100 R	92	85	96	83	94 R	82	90.0	Yes
	A	15	21	25	9	18	13	7	18	22	16.7	No
Remarks: Related groups C 25 and C 26 omitted from chi-square tests because of small size.												
L&FA	E	7	64	75	100 R	74 R	32	39	52	38	55.6	Yes
	A	0	0	0	6	1	7	0	2	9	3.5	No
Remarks: Wide variety in enrollment. Acceleration appears negligible, not enough data for chi-square test.												

E: Percentage of the curriculum group who enrolled in the given course.
A: Percentage of those enrolled who accelerated.
R: Columns indicate curriculums related to the basic course.

erating in related fields was low. But all groups showed extremely low acceleration in basic Literature and Fine Arts, 171; the related course for Fine Arts, C 50; which satisfactorily accounts for the low percentage. The related course for Phys. Ed., Health, and Rec., C 23; was basic Biological Science, 121, in which the average acceleration was quite high, indicating that in this case the low percentage is characteristic of the curricular group.

ANALYSIS OF DATA

Section 1. General Remarks. The chi-square test was used with all the data that has been described, to test the hypothesis that the differences among percentages for different groups could have

arisen from chance factors alone. A value significant at the 5 per cent or 1 per cent level indicates that the differences are large enough that they would occur only 5 per cent or 1 per cent of the time, respectively. From such chance factors; if such a value is obtained it is fairly safe to conclude that there are actual differences among the groups. A value of chi-square too small for significance leaves open the possibility that the groups do differ but that not enough data was available for the differences to be detected.

The chi-square test does not single out specific differences as having special importance. We have pointed out a number of differences without direct statistical support when they appeared important. While results have been stated in terms of percentages, all computation used actual numbers of students in the subgroups, thus taking into account the various sizes of groups. A limitation of the chi-square test is that it is not applicable when subgroups being compared contain fewer than five or ten people. This has precluded statistical testing of some of the data for the smaller curriculum groups.

Section 2. Discussion of the Data Presented in This Paper. The data were used for all groups except Social Service, C 26, the smallest one. A chi-square value of 17.086, with 6 degrees of freedom, was obtained. This is significant at the 1 per cent level.

Section 3. Type of Acceleration. The chi-square test was applied to the four largest curricular groups, Fine Arts, C 50; Language and Literature, C 52; Biological Science, C 55; and Social Science, C 57. Each was broken down into the subgroups having (1) related acceleration only, (2) NDR only, (3) both related and NDR, (4) no acceleration. A chi-square value of 28.936, with 9 degrees of freedom, was obtained. This is significant at the 0.1 per cent level. Curriculums Language and Literature, C 52, and Social Science, C 57, were related to more than one basic course, and there was some ambiguity in classifying an accelerated course as related or NDR, but similar statistical results were obtained either way.

Section 4. Enrollment and Acceleration by Curricular Groups in Each of the Basic Courses. This data required 14 separate applications of the chi-square test. For each basic course the test, corresponding to percentages E used the enrollment totals for all groups except Public Administration, C 25, Social Service, C 26, and Physical Science, C 56. There was enough variation in the remaining data to show statistical significance with the exception of Written and Spoken English, which has already been discussed. The tests corresponding to percentages A used the numbers accelerating and the numbers enrolled and taking all three terms. Groups Public Administration, C 25; Social Service, C 26; and Physical Science, C 56 were omitted here also; in addition Phys. Ed., Health, and Rec., C 23; and Fine Arts, C 50; were omitted in the case of physical science because of their small enrollment in the course. A chi-square value significant at the 5 per cent level was obtained for enrollment (percentages E) in History of Civilization. In the other significant cases, values of chi-square exceeded the 1 per cent level.

SUMMARY

(1) Curricular groups vary significantly in the amount of related acceleration in basic courses.

(2) Curricular groups are "related" to several different basic courses.

(3) The data indicate that in most of the basic courses there are substantial differences in the performance of students from different curricular groups.

(4) The differences among percentages for different curricular groups were supported by the chi-square test which revealed actual differences among the groups in per cent taking the course and per cent accelerating.

(5) Forty-seven per cent of the enrolled students in the eight curricula accelerate in one or more basics.

(6) In curriculums Social Service, C 26; Public Administration, C 25; Social Science, C 57; more than average acceleration occurs; while Language and Literature, C 52; Biological Science, C 55; Physical Science, C 56; have average acceleration. The Fine Arts, C 50; and Phys. Ed., C 23; have less than average acceleration.

(7) The group with the highest related acceleration were the sciences Biological Science, C 55; and Physical Science, C 56, along with Language and Literature, C 52.

(8) There was no tendency to hurry through the related basic course in the case of curriculum Fine Arts, C 50.

(9) Basic Literature and Fine Arts was avoided by Phys. Ed., Health, and Rec., C 23 and had limited enrollments from Biological Science, C 55, and Physical Science, C 56, the science students.

(10) Enrollment in Biological Science was about the same for Physical Science, C 56; Social Science, C 57, and RS, but they differed considerably in acceleration, with C 57, Social Science being highest.

(11) The group with the smallest enrollment in Social Science was Fine Arts, C 50.

(12) Phys. Ed., Health, and Rec., C 23, with a large enrollment in Social Science had zero acceleration.

(13) Biological Science, C 55, with an average enrollment in Social Science had very low acceleration.

(14) Fine Arts, C 50, had a low per cent enrollment in Effective Living, but chose to accelerate in the basic.

(15) The History of Civilization basic indicated more uniformity than most of the other basics. Enrollment was high for most of the groups.

PREDICTABILITY OF SUCCESS IN COLLEGE COURSES, BY ACCELERATING AND NON ACCELERATING STUDENTS AS MEASURED BY SCORES MADE BY ENTERING FRESHMAN ON A.C.E. AND COOPERATIVE READING TEST

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A STATISTICAL investigation designed to gather evidence concerning the relationship of the Basic College students to the various basic courses at Michigan State College is in press. Substantial differences in the performance of students from the different curricular groups is being reported. In 1950 studies were completed [1] showing accelerated students in Biological Science at Michigan State College make higher grades in advanced biology courses than do non-accelerated students. This was true even when achievement at the beginning of the advanced courses, and general learning ability were held constant. The question as to whether, this level of performance holds true for accelerated students in the Basic College as a whole, was investigated.

The project included all departments in the Basic College. Representatives from each department cooperated in the study.[2]

[1] Van Der Jagt, E. R., "Performance of Basic Biological Science students in advanced Biology courses," *Science Education*, Vol. 34, March 1950, No. 2, p. 85.

[2] People cooperating in the project: C. M. Babcock—Written and Spoken English—Basic 111, 112, and 113. *E. R. Van Der Jagt—Biological Science—Basic 121, 122, and 123. J. W. Zimmer—Physical Science—Basic 131, 132, and 133. J. O. Hall—Social Science—Basic 141, 142, and 143. †J. B. Holland—Effective Living—Basic 151, 152, and 153. † M. K. Farmer—History of Civilization—Basic 161, 162, and 163. V. E. Leichty—Literature and Fine Arts—Basic 171, 172, and 173.

* Coordinator and Leader.
† Deceased.

It is the purpose of this paper to present the findings of the investigation as it relates to the performance of seniors who did accelerate and those who did not accelerate their work in the Basic College.

TYPES AND SOURCES OF DATA

From the record files of the Registrar, the Board of Examiners, and the departments concerned, the following data on several hundred seniors were gathered:

1. Performance on the American Council Psychological Examination.
2. Reading performance. (Cooperative Test of Reading Performance.)
3. Senior grade point average, with and without acceleration grades.
4. Performance on a comprehensive examination in each Basic taken.

Each Basic College course consists of three sequential terms of study which are hereafter referred to as Terms 1, 2, and 3.

Students who attained sufficiently high departmental test scores and who demonstrated daily ability in the course to the instructor during the first term, or for terms 1 and 2, were allowed to accelerate their programs by taking the comprehensive examination without completing all three terms. Credit was granted if they earned a "C" or higher on the comprehensive examination.

There were seven basic college courses, which will be identified as given in the following list:

111–112–113 Written and Spoken English
121–122–123 Biological Science
131–132–133 Physical Science
141–142–143 Social Science
151–152–153 Effective Living
161–162–163 History of Civilization
171–172–173 Literature and Fine Arts

In consultation with the chairmen of the basic college departments, a list of eight curriculum areas was drawn up including at least one closely related to each basic course. These are given in the following list, together with identifying code numbers as used by the Registrar, and the numbers of the related basic courses.

Senior graduating students associated with the previously mentioned course relationship constituted the eight curricular groups. A ninth group was obtained by choosing names at random from a list of the graduating senior students in all other curricula. In all nine groups, transfer students and others for whom data were incomplete were dropped from the list and are not discussed in this paper.

The decile scores recorded on the students' permanent records are regarded as a measure of general college ability and general reading ability.

Grades at Michigan State College are of the traditional A, B, C, D, F type found on most campuses. Grade points conformed to the standard method of assignment: four grade points per credit for an A, three for a B, two for a C, one for a D and 0 for an F. Subgroups of all groups were roughly equated as to college ability by a random selection of an equal number of students from each rank (A.C.E.) and reading ability as determined by their rank in the reading test decile. These procedures for equating,

Curriculum Number and Description	Related Basic Number and Description	Graduating Number of Senior Students in Curriculum
C 23—Phys. Ed., Health, and Rec.	121 Biological Science	30
C 25—Public Administration	161 History of Civilization	14
C 26—Social Service	161 History of Civilization	8
C 50—Fine Arts	171 Literature and Fine Arts	50
C 52—Language and Literature	111 Written and Spoken English 171 Literature and Fine Arts	105
C 55—Biological Science	121 Biological Science	47
C 56—Physical Science	131 Physical Science	18
C 57—Social Science	141 Social Science 151 Effective Living 161 History of Civilization	126

sampling and scoring were used throughout the total study.

DATA

Below is a table showing the distribution of the 396 students for whom this data was available; number of hours of basic college acceleration and their all-college grade point average.

Regression and correlation relations among the four variables were then worked out. The variables being (1) A.C.E. decile (2) Reading decile (3) Grade point average (4) Number of hours of acceleration, based on the samples of 426 students, both accelerated and non accelerated, of all eight curriculum groups and the random sample for whom data were complete.

Grade Point Distribution	Number of Hours of Acceleration				Number of Students
	0	3	6	over 6	
1.9 – 2.19	44	15	9	6	74
2.2 – 2.49	99	20	17	6	142
2.5 – 2.69	31	6	9	9	55
2.7 – 2.89	19	6	11	5	41
2.9 – 3.29	17	7	10	20	54
3.3 and over	4	6	7	13	30
Total	214	60	63	59	396

In this table data has been grouped, making it possible to use chi-square to test independence of acceleration and grades. The result of the chi-square test equals 78.19 with 15 degrees of freedom. This is significant at 0.1 per cent level, indicating an extremely high probability that grades are not independent of acceleration. This becomes a partial check of the regression analysis, as presented later, which indicates that grades depend significantly on acceleration.

Additional data follows for the eight curricular groups and the random sample. First the combined data is presented. This is followed by the chart giving the breakdown for each of the nine subgroups.

Mean Values:		Standard Deviations
(1) ACE decile	5.899	2.790
(2) Rdg. test decile	6.340	2.761
(3) G.P.A.	2.532	2.057
(4) Hours Acc.	3.387	1.689

Correlation coefficients (subscripts indicate the two variables involved)

$r_{12} = 0.759$
$r_{13} = 0.287$
$r_{14} = 0.381$
$r_{23} = 0.296$
$r_{24} = 0.423$
$r_{34} = 0.288$

Partial correlation coefficients, showing correlation between each two variables after eliminating the influence of the variables not involved (in effect, holding the other variables constant).

	Accelerated	Non Accelerated	Total
Total number of students	196	230	426
A.C.E.	7.026	4.939	5.899
Rdg.	7.566	5.296	6.340
Actual G.P.A.	2.635	2.444	2.532
Hours of acceleration	7.308	0	3.387

MEDIAN VALUES OF THE ENTRANCE DECILES (ACE & R); GRADE POINT AVERAGE AND THE AMOUNT OF ACCELERATION, FOR EACH CURRICULAR GROUP WITH ITS SUB GROUP OF ACCELERATED, NON ACCELERATED AND TOTAL GROUPS

Mean Values	23_A	23_N	23_T	25_A	25_N	25_T	26_A	26_N	26_T	50_A	50_N	50_T	52_A	52_N	52_T
Number of students	5	22	27	7	6	13	5	3	8	17	29	46	47	52	99
ACE decile	2.75	2.33	2.50	8.50	6.50	7.75	4.75	4.25	4.5	7.38	4.75	5.80	7.50	5.11	6.05
Rdg. test decile	4.25	1.83	2.25	8.75	5.50	8.17	7.50	2.75	7.50	8.10	4.17	5.75	8.25	6.22	6.88
GPA	2.22	2.38	2.35	2.61	2.27	2.45	2.70	2.50	2.62	2.89	2.60	2.70	2.63	2.45	2.53
Avg. No. of hours of acceleration	7.80	0	1.45	8.14	0	4.38	4.20	0	2.62	5.12	0	1.89	6.06	0	2.88

Mean Values (Continued)	55_A	55_N	55_T	56_A	56_N	56_T	57_A	57_N	57_T	RS_A	RS_N	RS_T
Number of students	19	22	41	8	10	18	64	56	120	24	30	54
ACE decile	7.50	4.50	6.70	6.67	6.67	6.67	7.20	3.60	5.92	5.50	3.00	3.83
Rdg. test decile	7.58	5.00	6.83	7.00	6.33	6.60	8.15	4.91	6.71	6.33	3.17	4.00
GPA	2.70	2.48	2.58	2.60	2.48	2.53	2.63	2.45	2.55	2.50	2.32	2.40
Avg. No. of hours of acceleration	6.16	0	2.85	10.88	0	4.83	9.00	0	4.80	7.25	0	3.22

$r_{12.34} = 0.702$
$r_{13.24} = 0.083$
$r_{14.23} = 0.085$
$r_{23.14} = 0.084$
$r_{24.13} = 0.203$
$r_{34.12} = 0.180$

DISCUSSION OF CORRELATION COEFFICIENTS —DATA

The correlation coefficients reveal that all are significant at 5 per cent (or 1 per cent) level. Using a different approach, we can say with 95 per cent confidence that the population values lie within 0.100 of these sample values and somewhat closer for some of them.

BUT—part of the high correlation indicated here between, say, (1) ACE decile and (3) grade point average, may be due indirectly to the other variables, which are usually high when (1) is high and low when (1) is low. What is the correlation between (1) and (3) when the others, (2) and (4), are *held constant?* This is given by the *partial* correlation coefficient, $r_{13.24}$ in this case.

These are not all significant. However, at this time, I wish to point out that holding variable (2) constant, greatly reduces the variance of variable (1) and this reduces the probability of (1) correlating highly with the other variables. Likewise the same effect when (1) is held constant.

As with the ordinary correlation coefficients, we can say with 95 per cent confidence that the population values are within about 0.100 of these samples values, and there is no evidence that either (1), ACE decile or (2), rdg, decile, is correlated with (3), grade point average, or that (1), ACE decile and (4), acceleration are correlated.

Regression equation: The following is the best linear equation for estimating mean value of any one of the four variables when the other three are known. $G = 2.532 + .0177\ (A - 5.899) + .0186\ (R - 6.340) + .0154\ (H - 3.387)$.

Notation: A = ACE decile
R = Rdg. test decile
G = Grade point average
H = No. hours acceleration in basic courses

The question of how good this estimate is, is answered in part by the following remarks.

The standard error of estimate of G is a measure of the variability of G when the other three quantities are held constant. It is found to be 1.92. This is smaller than the standard deviation 2.06, indicating a small but significant increase in accuracy of prediction when A, R, and H are taken into account. Another measure of accuracy of the estimate is the multiple correlation coefficient, which can be interpreted either as giving the correlation between the actual grade point values and those predicted by the equation, or as a measure of the dependence of G on the other three quantities. It has the value .355. It may be of interest to list the coefficients for A, R, and H. They are as follows:

A: .764 R: .775 H: .462

Note: The validity of this equation and of all statements on significance depends on the assumption that the four variables are all distributed normally.

The regression equation as given above is in a form which shows explicitly the average values of the numbers involved. While this may be of theoretical interest, the following is suggested as a simpler computation procedure for predicting grade point average.

(a) Form average of the two decile figures and multiply by .0363.

(b) Multiply number of hours acceleration by .0154.

(c) Add results of (a) and (b) to 2.26.

The figure 2.26 could be interpreted as the estimated grade of a student with zero decile rating and no acceleration. If the student increases the average of his decile ratings, we raise this estimate by .0363, for each increase of 1. Similarly we raise the estimate by .0154 for every hour of acceleration. .0363 is the sum of the numbers .0177 and .0186 appearing in the equation, which are so nearly equal that combining them has no appreciable effect on the estimate.

Example: Student with A = 6, R = 4, and 6 hours acceleration.

(a) Average of 4 and 6 is 5. $5 \times .0363 = .1815$.

(b) $6 \times .0154 = .0924$.

(c) $2.26 + .1815 + .0924 = 2.5329$, or approximately 2.53, the predicted grade point average.

Reliability of equation: This equation indicates that entrance test deciles have a rather small influence on G.P.A. In fact, the deciles enter into the equation to a degree too small to be quite significant at the 5 per cent level. The influence of H, (hours of acceleration) seems to be significant at the 5 per cent or 1 per cent level. Since the correlation coefficient of this estimate with G, the quantity being estimated, is only .355, there are evidently other factors besides the three taken into account in this estimate.

SUMMARY

1. Students in the Basic College, as a whole, who accelerate in the basics make higher grades in advanced courses than do non-accelerated students.

2. The evidence from the partial correlations does not indicate that either the A.C.E. decile or the reading decile is correlated with the grade point average, i.e., no significant correlation when certain variables are held constant.

3. The evidence from the partial correlations does not indicate that the A.C.E. decile and acceleration are correlated, i.e., no significant correlation when certain variables are held constant.

4. The influence of hours of acceleration upon grade point average seems to be significant at the 5 per cent or 1 per cent level.

5. The multiple correlation of entrance decile and hours of acceleration with grade point average is only .355 which indicates that there are other factors besides these three for predicting final success.

6. The correlation coefficients and prediction equation shows to what extent the grade point depends on acceleration and entrance scores.

CHANGES IN NARST POSITIONS

Professor S. Ralph Powers is Visiting Professor at the University of Florida, Gainesville, Florida during the First Semester, 1956–57.

Dr. Katherine E. Hill, School of Education, New York University, is on sabbatical leave during the school year 1956–57. She is making a tour of the world.

Dr. Finley Carpenter, formerly of Michigan State University, has accepted a position in the School of Education, University of Michigan, Ann Arbor, Michigan.

Dr. Stanley B. Brown, formerly of the School of Education, University of Colorado, is now in the School of Education, University of California, Berkeley, California.

Dr. William Harrison Lucow is now Associate Professor in the Faculty of Education, University of Manitoba, Winnipeg, Manitoba, Canada.

Professor Edna W. Bailey, University of California, will spend the winter traveling in England, Italy, and France.

Dr. Anita D. Laton, formerly of San Jose State College, San Jose, California, has as her new address: 1022 Spruce Street, Berkeley, California.

Professor Bertha M. Parker has as her present address: 5705 Blackstone Avenue, Chicago 37, Illinois.

Professor Earl R. Glenn is spending the year at his home in Vevay, Indiana.

Dr. F. A. Riedel has moved to a new address, following the death of Mrs. Riedel last April. He is now living with his son, a professor at Purdue University. His new address is:

101 Leslie Avenue
West Lafayette, Indiana

The new address of Dr. Francis St. Lawrence is:

3731 Lewis Street
Long Beach, California

A new name and a new address for a well known NARST member is:

Mrs. Archie MacLean Owen
6855 No. Longmont Avenue
San Gabriel, California

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